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Editor
ROY WALDO MINER

Associate Editor
JAMES A. GOODE

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Executive Director: EUNICE THOMAS MINER

SECTION OF GEOLOGY AND MINERALOGY

TECTONIC TEAM-RESEARCH, KEY TO SOCIAL PROGRESS AND WORLD-PEACE*

By W. T. THOM, JR.†

"And this our life, exempt from human haunt,
Finds tongues in trees, books in the running brooks,
Sermons in stones, and good in everything."
As You Like It. Act II, Scene 1.

Introduction

Expanding supplies of ores, coal, petroleum and other minerals are indispensable to social progress and world peace. To maintain increases in rates-of-discovery will require progressively better-trained explorers and more of them. Such new geo-exploratory recruits can best be developed by having them serve as apprentices in basic tectonic team-research projects (such as the one which will be described by the writer).

Since 1929, a team-study of the processes responsible for mountain-building and for production of typical tectonic features and patterns, has been conducted in the Yellowstone-Bighorn region of Montana and Wyoming by a volunteer group of geologists and geophysicists. Approximately 500 man-seasons of field work have so far gone into this cooperative project and this article represents a summary preview of the group's findings. My decision to attempt such a summary at this time has been guided partly by the belief that our studies have yielded interesting, though tentative, results and, more particularly by the conviction that our experimental effort has proven that geological-geophysical educational research can provide a key to social progress and world peace. This overshadowing aspect of the total problem will be developed briefly in the concluding portion of the paper, after a preliminary review both of the primary results yielded by our educational group-research, and of the objectives and general operational methods of the informal, out-of-door university which evolved as a result of the prosecution of these cooperative studies.

An Experimental Out-Door University—Purposes and Functions

The decision to create an informal, out-of-door university as the vehicle best suited to the accomplishment of our projected exploratory research was guided by three major considerations. The first was the realization that geologists and engineers, because of their pioneering functions, carry unique responsibilities for the advancement of knowledge, and for the effective use of the arts and sciences in the public service. The second consideration was that university faculty members are similarly responsible for converting knowledge into understanding, and for such training of students that they, in turn, may progress successfully along the frontiers of understanding. Finally, it was felt that both groups are under obligation to make suitable public reports of their findings (especially on matters having a decisive impact upon questions of national and international policy), in order that such policies may have not only valid scientific and factual bases, but be drawn so as to be operable according to sound engineering principles and practice.

Methods Used in Team-Study

As already indicated, the method used in our tectonic team-study has been that of a "primitive university," wherein the basic effort has been initiated, planned, and operated by an informal volunteer group of advanced scholars drawn and held together by common research interests and by the consequent opportunities for mutual education. As a corollary to this development, younger faculty members and graduate students have received advanced training while acting as junior research colleagues in charge of unit studies component to the overall project. In addition, undergraduate and pre-college participants have had exceptional opportunities for acquiring both knowledge and understanding, while serving as apprentices and disciples-in-research to more experienced party chiefs. Through the use of this methodology, every dollar spent has yielded a dollar's worth of results in each of three lines of interest—scientific, educational, and operational; and because three dollars' worth of results have been obtained for each dollar expended, it was

* This paper was presented at the meeting of the Section on January 7, 1952.

† Department of Geological Engineering, Princeton University, Princeton, N. J. President, Yellowstone-Bighorn Research Association, Inc., Red Lodge, Montana.

possible to continue to finance and develop the total operation even during the Depression, and despite the distractions resulting from World War II. Researches conducted have been financed partly by grants-in-aid from scientific organizations like The Geological Society of America; partly by direct, or indirect, allocation of university research moneys, including Higgins Bequest funds provided through Princeton University; and partly by research or scholarship funds provided by oil companies, by the Northern Pacific Railway, and by citizens and civic organizations of the region studied. They have also been greatly aided by the "match-moneys" and other funds used by various Federal and State organizations for the conduct of particular cooperative activities undertaken in connection with our total regional effort.

Prime Purpose of Research

The central scientific purpose of our team-research has been to make convergent attacks upon the problems connected with the origin and growth of mountain systems. To achieve this aim we have sought to decipher the evolutionary history of a typical mountain (and mountain-border) region in order that we might learn when, how, and why the Earth's crust within this particular area had been transformed from a level sea-floor into a system of basins separated by elongate ranges. The mountains had been injected by plutonic igneous rocks from which major ore-bodies have originated, and the basins have become loci for coal-formation and oil-accumulation.

Reasons for Use of Team-Method in Tectonic Study in Yellowstone-Bighorn Region

Considering the magnitude of the undertaking, employment of team-research as a means of accomplishing a thorough study of a whole mountain region was obviously necessary, for an extensive study of tens of thousands of square miles of rugged country was clearly too large a task to be successfully performed by any individual within a human life-time. Also, since many specialistic phases of geology and geophysics were involved in the needed explorations, the operation could be carried forward successfully only by groups of cooperating specialists, working according to overall plans, and under a leadership which had been developed by common consent. The "central committee" thus evolved, proceeding according to the old maxim "work from the known to the unknown, and from the simple to the complex", decided to begin its operations in south-central Montana by undertaking a study of the physical evolution of the Bighorn Basin and its surrounding uplifts. This was done because eastern and central Montana and northern Wyoming were already areas of relatively well-known geology, due to long-continued studies by many geologists and geo-exploratory organizations. The areas under consideration also comprised a total region within which it would be possible to work successively from the slightly deformed plains of the Dakotas into the moderately deformed basins of eastern Montana, and Wyoming; thence into the more strongly compressed areas of the Bighorn Basin and central Montana; and finally into the intensely deformed regions of western Montana, eastern Idaho and western Wyoming. These regions include both the volcanic centers in Yellowstone Park and its vicinity, and the related centers of batholithic intrusion which feature the mining regions of western Montana, Idaho, eastern Washington, and British Columbia.

Seven Main Phases of Tectonic History of Yellowstone-Bighorn Region

The known deformational history of the Yellowstone-Bighorn region and surrounding areas is divisible, naturally, into seven main tectonic phases.

Phase 1. The known tectonic history of the Yellowstone-Bighorn region begins with an early Pre-Cambrian or Archeozoic orogenic phase, during which geosynclinal sedimentation was followed, successively, by mountain-building compression; by batholithic intrusion; and by the development of several regional fracture systems which subdivided the basement rocks of the area into a mosaic of well-defined blocks.

Phase 2. During the second phase, embracing a relatively long period of post-orogenic crustal stability, active erosion effectively truncated the rocks of the region, producing a lowland underlain by the bevelled roots of the previously-formed mountain ranges.

Phase 3. During the period between late Pre-Cambrian and Permian times, broad geosynclines-of-sedimentation were developed within western Montana and Idaho by down-warping of this antecedent (Pre Cambrian) erosion surface, and, as time elapsed, shallow shelf-seas spread thence eastward and northeastward to Minnesota.

These shelf-seas were featured, from time to time by local islands and peninsulas, recurrently produced by minor vertical crustal readjustments along one or more early Pre-Cambrian basement rifts.

Phase 4. During the fourth, or Nevadian-Laramide phase, repeated pulses of explosive volcanism, compressional deformation and batholithic intrusion began to be felt near the Pacific Coast in Triassic time. Throughout Jurassic and Cretaceous time, the zone of maximum Laramide compression and thrusting shifted eastward, step by step, until it reached its culmination at the end of the Paleocene in the eastern Front Ranges of the Rockies.

Phase 5. During the fifth, or "readjustment", phase following the Laramide orogenic period, the Cordilleran region maintained a general average state of regional depression, despite the antecedent up-bowing or thrusting and uplifting of individual, linear ranges. During the Eocene, deep valleys were cut by rivers within and between the newly-elevated mountains, and playa and salt lake deposits were accumulated on the floors of the deeper intermontane basins. During the Oligocene and first half of the Miocene, materials eroded from the range crests, together with enormous quantities of volcanic ash and dust, filled the intermontane basins so deeply that these basin fills first lapped against the inter-basin ranges and then actually buried the lower portions of their crest lines.

Phase 6. During the sixth phase of Rocky Mountain evolution, corresponding to later Miocene (and possibly Pliocene) time, a state of post-orogenic crustal equilibrium had been approximated, and a regional system of pedimentary surfaces had been developed at grade *i.e.*, at an altitude only a little above sea level. The pediments of this system indiscriminately truncated both the softer basin and valley-fills and the intervening hard-rock ridges and ranges; and the major streams of the area meandered at random across the resultant, gravel-coated pedimentary surfaces.

Phase 7. The seventh, and final, phase of the physical evolution of the region began either in the Pliocene or early Pleistocene and was marked by vertical, upward movement, which caused a broad up-arching of the whole Great Plains and eastern Cordilleran region. This up-arching led to the relative subsidence of keystone fault-blocks in the Great Basin and Western Montana areas, and initiated a notable cycle of canyon-cutting, of drainage change, and of basinal re-excavation; thus again restoring to commanding prominence the present snow-capped mountain ranges, and giving skylines which caused the Plains Indians of the Lewis and Clark days to speak of Montana as "The Land of Shining Mountains."

Nature and Genesis of Laramide Tectonic Features

First-order Features and Forces. The dominant Laramide compressional forces were applied in directions essentially perpendicular to the trend of the American Cordilleran system, which extends from Alaska to Antarctica by way of Cape Horn and the Southern Antilles. In other words, these forces were applied within the western United States in a general ENE-WSW direction, involving within this region three first-order tectonic features: (1) the North American continental shield or crustal plate on the east; (2) a comparable North Pacific sub-oceanic shield on the west; and (3) the Cordilleran orogenic zone, or strip of more mobile crustal rocks, lying between.

Second-order Tectonic Units. An inspection of a tectonic map of western North America discloses, at once, that this total (first-order) Cordilleran orogenic zone has been naturally divided into component second-order tectonic features or structural provinces. The latter have resulted from variations in the yield-characteristic of their respective crustal segments, which in turn differed either in the nature or in the three-dimensional arrangement of their constituent strata and rock masses. For example, Laramide compressional flexing of the thick, stiff, Beltian, geosynclinal deposits produced a characteristic fault-range pattern throughout northwestern Montana, which contrasts markedly with: (1) the range-and-basin pattern characteristic of the eastern Rocky-Colorado Plateau province; and (2) the system of batholithic intrusions and associated arcuate thrusts which feature the wedge-shaped area in western Montana situated between the convergent Osburn-Lake Basin and Jefferson Canyon-Ross Peak rift zones.

Third-order (Unit Block) Tectonic Features. In nature, finite blocks of crustal material have been deformed as units by regionally-applied compressive forces, just as in a materials-testing laboratory, distinct and separate unit-blocks respond independently to the action of a testing machine. As in the laboratory, these forces produce within different blocks various well-known

strain and rupture patterns, according to the nature, form, and geometric arrangement of the material tested; its temperature; and the rate and manner of force application. Just so, within the second-order tectonic region, lying southeast of the Little Belt axis, in Montana, where three main types of crustal block-units, or "third-order tectonic features", had been defined by Pre-Cambrian rifting and intrusion. These were: (1) "the positive" blocks, or crustal plates, which either tended to be domed by Laramide intrusion, or be uplifted and tilted by Laramide compression; (2) local downward or upward pointing crustal wedges, which were respectively elevated or depressed by orogenic thrust; and (3) the larger, sub-basinal, crustal plates which were forcibly flexed downward into basin form by regionally-applied compression; which simultaneously caused active inter-basinal competition along the intervening rim-uplifts. This resulted in limited overthrusting or underthrusting, depending upon the local ascendancy of one basin or the other, as the whole assemblage of crustal plates was forced together, often with some horizontal rotation of individual basin-blocks.

Mechanical Development of Fourth, Fifth, Sixth, and Seventh-order Features. Because of the near-surface crustal shortening forced upon third order (sub-basinal) plates by the regionally applied forces, each resultant Rocky Mountain basin tends to be featured by either several, or many, fourth-order asymmetric anticlines, which owe their form and distribution directly to the operation of basin-mechanics within each parent basin. Such asymmetric anticlines are not folds in the usual sense, since they are not separated by intervening synclines, and are elongated in directions related to the trend of the contiguous basin rim, without having their trend-directions related in any immediate or direct way to the orientation of the first-order Laramide compressive forces. Such fourth-order anticlines, in their embryonic and juvenile stages, operate as single mechanical or tectonic units, but at adolescence become riven by systems of epi-anticlinal faults into fifth-order systems of mechanical unit-blocks, which thereafter move and yield quite independently of each other.

Continuing deformation of such fifth-order unit-features will, in turn, produce sixth-order drag-folds and joint systems, and continued deformation of sixth-order features, likewise will give rise to morphologically similar seventh-order features, of hand-specimen to microscopic size.

Relations Between Volcanism, Vulcanism and Laramide Mountain-building Activity

That direct causal relations exist between explosive volcanism, crustal deformation, batholithic intrusion, and deep-seated sub-crustal igneous activity is probably not yet demonstrable to the satisfaction of all, but is indicated by field evidence. The evidence suggests that the tectonic and igneous activities of the Laramide disturbance gave rise to four parallel, though widely-spaced (perhaps arcuate), deformational waves, each of which shifted eastward by one wave-length with each new episode of Laramide crustal disturbance. The zone thus occupied by the first of such waves was featured by explosive volcanic eruption, productive of dust and of bentonitic ash beds; the second, situated a hundred miles or so farther west, was featured by laccolithic intrusions and by less explosive volcanic outpourings; the third (orogenic) wave, situated another 100 to 200 miles farther west, was characterized by large scale thrust-faulting, causing the elevation of linear mountain ranges; and the fourth zone (of batholithic intrusion), was one wherein great bodies of magma became emplaced somewhat west of (*i.e.*, behind) the recently active zone of thrust-fault development.

It is fairly certain that notable and progressive increases in sub-crustal temperatures had taken place in each region, before that region began to show signs of yielding to the onset of compressional deformation; and it is equally probable that the progressive development of large scale magmatic blisters beneath or within the earth's crust was an indispensable preliminary to the production of the large scale thrust faults which subsequently developed. This seems clear where the formation of large thrusts was closely associated, both in time and space, with the emplacement of major batholithic masses, as has happened in the Phillipsburg and Butte areas of Montana.

Moreover, the Tertiary cycle of volcanic eruption, the effusion of the Snake River and Columbia basalts, and the Quaternary uparching of the whole eastern Cordilleran region all point to a sudden renewal of heat and vapor outflow from sources lying far below the crustal rocks of that region. Such heating causes an isostatic rise of the total area, consequent upon the thermal ex-

pansion of its subjacent rocks, with a resultant regional decrease of bulk specific gravities. (Conversely continued cooling of a region would induce increases in bulk specific gravities and could cause a former continental area to subside to a sub-oceanic level.)

Conclusion

Tectonic Team-research as the Key to Social Progress and World-peace. It is possible to understand why and how tectonic team-researches such as have been described may provide the key to social progress and world-peace, if one simultaneously considers the case illustrations offered by Athenian history, by Roman and British Imperial development, and by the evolution of the modern United States.

Athenian cultural glory was actually based upon the fabulous treasures of silver yielded by the city-owned mines at Laurium; mines where subsequent re-development found more than 2000 shafts and more than 100 miles of underground workings. Athens also rose to political ascendancy through the hiring of mercenaries, and through the subsidization of its co-members in the Pan-Hellenic League, only to collapse to the status of a semi-ghost town when her silver mines were exhausted.

Roman economy and political power were based upon the production of various metals, used to forge the tools of peace and the weapons of war. The Romans had skilled prospectors and expert miners but lacked pumping machinery, and their mines had to be abandoned after they went slightly below water-level. Consequently, they were forced farther and farther abroad in order to obtain the metals they needed. Because they used the imperial (or exploitationist) pattern for expanding their mining operation, instead of the recently-devised and constructive methods of "welfare capitalism," the territories under their control progressively came to include a greater number of regions inhabited by subjugated but hostile peoples. Finally, their economic, political, and military over-extension became insupportable, and the Empire, which once had been able to enforce a Pax Romana over the whole Mediterranean world, collapsed of its own weight.

British industrial and naval power, brought into being by the First Industrial Revolution, and founded upon the temporary pre-eminence of Britain as a producer of coal and metals, began to rest upon increasingly shaky foundations when oil began to replace coal as naval fuel, and as British industry, for its very existence, began to depend increasingly upon imported supplies of essential minerals drawn from remote regions.

The United States rose to pre-eminence as the world's foremost industrial and military power on the strength of the Second, Third and Fourth (Automotive, Chemical, and Tele-Communications) Industrial Revolutions. These were backed by our ability to produce great volumes of coal and petroleum; by our great output of many essential ores and mineral raw materials; and by our ability, under shelter of the British Navy, to import the needed supplementary supplies of other critical mineral substances. However, since 1920, our growing industrial dependence upon a continuous and assured availability of an expanding list of imported mineral raw materials has given stark emphasis to our extending domestic insufficiency with respect to various critical mineral commodities; a situation which makes us increasingly vulnerable to political and economic pressure and to threats of interdictive military attack. In fact, the United States is now in such a position that we are not justified in hoping even to maintain our present precarious economic, political, and military *status quo* for any considerable period of time.

However, we need not be greatly discouraged to learn that, in addition to us, Britain, western Europe, Canada, and the other nations experienced in self-government, all are in a similar state of acute and growing industrial and political instability. A suitable regional federal grouping, within the UN charter, can certainly provide an immediate and satisfactory solution for the world's short-term problems which relate to present critical mineral shortages and to present difficulties involving currency and commodity exchanges. Exploratory tectonic team-research, coupled with technologic research and development, can also provide satisfactory solutions for our long-term problems of critical-mineral supply. With respect to petroleum this has already been proven true by the successful team-efforts of the geo-exploratory workers, technologists, and executives of the petroleum industry who together have wrought an amazing transformation, commented on by the late J. Edgar Pew in his address: "Fifth Dimension in the Oil Industry."

In conclusion, present-day prosperity and future world-peace can only be assured by voluntary regional federations of self-governing peoples, as permitted by the UN charter. Continuing

peace and progress can be maintained with the realization, of the public at large, that modern civilization, like the giant Antaeus, draws its strength from the earth, and that the proper functioning of the exploratory and extractive industries is an indispensable prerequisite in properly maintaining the foundations of civilization. This prerequisite will be met, providing that suitable university and industrial cooperative arrangements make it possible for adequate numbers of able young men to learn the advantages of competitive cooperation through participation in team-research within both science and industry. Particularly through participation in tectonic team-studies can the world's available supplies of essential minerals continue to expand from year to year, despite the ravages of depletion, and despite a continuing rise in the world's total requirements for essential mineral raw materials and for mineral sources of energy.

SECTION OF PHYSICS AND CHEMISTRY

THERMAL AND PHOTODEGRADATION OF VINYL POLYMERS*

By ROBERT SIMHA†

The fundamental mechanism and kinetics of free radical polymerization reactions are now well established, thus making possible both the evaluation of absolute rate constants for a number of systems and valuable generalizations as to the relation between structure and reactivity. The picture in respect to depolymerization appears more confusing because of the very different behavior of unlike polymers. While, for instance, the thermal polymerization of styrene and methyl methacrylate proceeds in a quite similar manner, the polymers pyrolyze in a very different fashion. Since the end of the war, important experimental investigations have been carried out in several laboratories. These have given impetus to the development of a theory of thermally and photo-initiated depolymerization processes, and our main purpose is to discuss the fundamentals of this theory. One important limitation will be imposed: we are concerned only with a breakdown of the chain backbone. This restriction excludes a study of systems such as polyvinyl chloride, where the main process consists of a removal of pendant groups.

The principal quantities available for measurement are: (1) the overall rate of evolution of monomer and other small vaporizable species; (2) the rate of decrease of the average molecular weight of the residue; and (3) the yield of pure monomer. Upon analysis in a mass spectrometer of the volatiles coming off at temperatures between 200–400°C (depending on the polymer), and pressures of 10^{-6} mm Hg, one finds that only a fraction of these consist of pure monomer. The rest contain "foreign" fragments, *i.e.*, methane, toluene, and others.

What then is the experimental situation? The polymers studied can be arranged in a kind of hierarchy or spectrum in respect to all three quantities. On one end methyl methacrylate is to be found, on the other, polystyrene and polyethylene.[1–3] The change of average molecular weight $\bar{M}$ with conversion C (fraction of initial material converted to volatile products) is comparatively slight for the ester. In molecular weights below 10^5 hardly any decrease is observed for the first 40 per cent or more conversion. In polystyrene, however, a sharp drop occurs within the first 10 per cent. The monomer yields are equally diverse, as seen in TABLE 1. Again, polyethylene and methyl methacrylate form antipodes; with hardly a trace of monomer in the former. It is interesting to note that the substitution of a CH_3-group in the backbone shifts the position in the table from top to bottom (*viz.*, compare styrene *vs.* α-methyl styrene), and *vice versa* (*viz.*, methyl methacrylate *vs.* methyl acrylate). The substitution of D has a similar, although less pronounced effect. Substitution in the ring, as in paramethyl styrene, has no influence on the yield.[4] Furthermore the rates are higher for methyl methacrylate, although the temperatures are some 100°C lower than in the pyrolysis of polystyrene.

These, then, are the essential facts the theory must account for quantitatively. In considering the possibilities of decomposing a long chain molecule, the simplest assumption is that all force constants and dissociation energies of the bonds

* This paper illustrated with lantern slides, was presented at the meeting of the Section on January 8, 1952.

† Department of Chemical Engineering, New York University, University Heights, New York, N. Y.

to be attacked are equal. On the basis of classical statistics, which should be adequate, the consequence is that all links are equally likely to break, regardless of the chain length and of their position.[5] Indeed, this assumption of a random degradation explains in the main the non-bacterial hydrolysis of linear polysaccharides. It yields a molecular weight curve quite similar to that for polythene, and describes the molecular weight distribution of the volatiles, provided one properly accounts for the fact that large fragments, of the order of 70 CH_2-units, can evaporate.[6] Such a mechanism obviously gives a low yield of small species, and preferentially intermediate sizes, until the last stages of the reaction.

In attempting an explanation of the slow molecular weight drop and the rapid evolution of volatiles observed, the author suggested some 10 years ago, a preferential or exclusive breaking of terminal bonds.[7] This results in a linear decrease of molecular weight with conversion but is not sufficient to describe all possibilities. For this, a whole spectrum K_i of decomposition probabilities must be assumed, where i indicates the position of link number i in the chain. This, however, represents only a formal solution of the problem. It is true that a consideration of the zero-point energies in low molecular weight hydrocarbons gives different decomposition rates for ethane and, for example, propane and butanes.[8] The latter two actually pyrolyze more rapidly than the former to an extent[9] which may be indicative of real differences in the bonds. With increasing size, however, these differences decrease, and in very long chains they should be unimportant. Even accepting the picture of a distribution of bond strengths, the differences in monomer yield still remain to be explained.

So far, we have argued on the basis of a step reaction, consisting of the iteration of a single step, the rupture of a bond. It is well known that the thermal decomposition of low molecular weight hydrocarbons can proceed by a chain mechanism and be catalyzed by the presence of free radicals. Furthermore, we must be able to establish a bridge between the reactions which form and destroy the molecule. A chain theory, which accounts for the above facts and avoids the difficulties of interpretation, was developed by Wall, Blatz, and the author[10] and has since been considerably extended.[11] The chain mechanism leads naturally to a spectrum K_i, however, only as a purely statistical effect, which has nothing to do with weak points.

The elementary acts of the chain reaction are shown in equation 1:

$$\sim CH_2-CHX-CH_2CHX\sim \xrightarrow{k_1} \sim CH_2-CHX\cdot + \sim CHX-CH_2\cdot \text{; Initiation}$$

$$\sim CH_2-CHX-CH_2-CHX\cdot \xrightarrow{k_2} \sim CH_2-CHX\cdot + CH_2-CHX \text{; Propagation}$$

$$\sim CH_2-CHX\cdot + \sim C(X)-CH_2-CHX-CH_2 \xrightarrow{k_3} \sim CH_2-CH_2X + \sim CX=CH_2 + \cdot CHX-CH_2\sim \text{; Transfer}$$

$$2 \text{ radical} \xrightarrow{k_4} 2 \text{ polymer; Termination.} \qquad (1)$$

The initial production of a radical has been depicted as the break of a C—C bond, but it may also consist of an attack on an impurity in the chain, such as a catalyst fragment. The observed dependence of the rate on molecular weight makes it necessary to assume that the initiation can occur either at random or only at the chain-ends. The propagation is the reverse of the growth step in polymerization. The transfer stabilizes a given radical and produces a new one by removal of an H-atom or other labile group, as in polymerization. Due to the high temperature, this is followed by a split into a shorter radical and stable molecule. Transfer, here, is a composite process and acts in two ways, by stopping propagation, and by attacking a second molecule at random. Furthermore, monomer units are changed, due to the removal or addition of substituents. This accounts, qualitatively, for the observed parallelism between low monomer yield and sharp molecular weight drop, as observed in polyethylene. "Impurities" are also created by the termination, assumed to be a disproportionation: in all instances they appear at the chain ends. It may seem at first sight that the kinetics ensuing from equation 1 is merely the reversal of the simple polymerization kinetics; but this is not the case. It is more complicated because of the production of intermediate species which can be reactivated. In the build-up process a stable chain, once formed, is assumed to remain dead. In addition, the initial size of the degrading molecules imposes a boundary condition.

Two parameters are characteristic for the system. The first, ϵ, is defined as:

$1/\epsilon - 1$ = propagation probability/(transfer + termination) probability. This quantity represents the number average length of a "zip" which splits monomer units off the radical. It is the analog of the degree of polymerization in the growth reaction. As the second parameter, one may choose the kinetic chain length, *i.e.*, the ratio between propagation and termination or:

σ = probability of transfer/probability of initiation. $\sigma/2$ is merely the number of transfer acts taking place during the life of a kinetic chain.

monomer (produced by propagation) and non-monomer and ϵ, valid, at complete conversion:

$$r = \tfrac{1}{2}(1/\epsilon - 1) \qquad (2)$$

This neglects intramolecular transfer which increases the propagation and at the same time reduces the monomer yield. Accordingly, equation 2 gives a lower limit for $1/\epsilon$. The impurities produced during polymerization are negligible except in cases of high monomer yield, where the evaluation of r becomes, in any case inaccurate. The resulting ϵ-values are exhibited in TABLE 1.

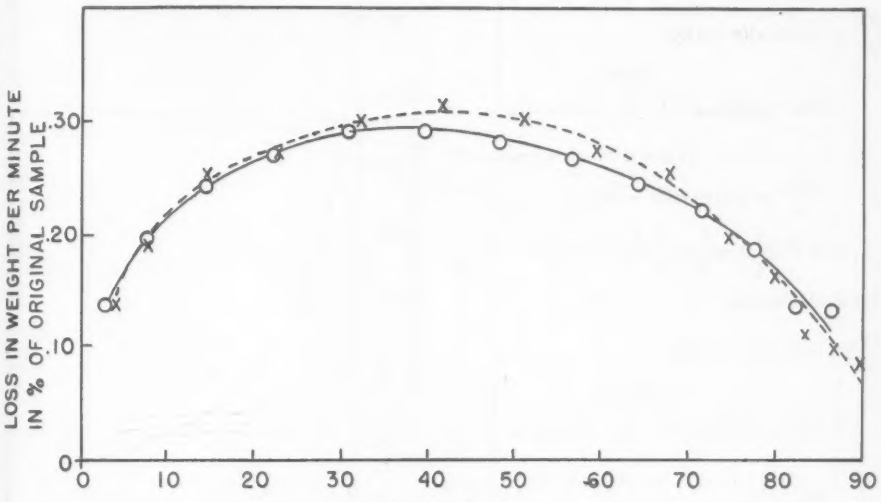

FIGURE 1 Rate of conversion as a function of conversion for polystyrene at 350°C, ref. 12. Duplicate runs.

The magnitude of ϵ can be estimated from the monomer yield in the following manner. In all cases investigated, one finds as the endproduct of pyrolysis essentially two fractions, one of them a wax-like material at room temperature. Cryoscopic determinations indicate a molecular weight of the order of several hundred. The other, a gas at room temperature, contains a distribution of smaller species, including monomer, as revealed in the mass spectrometer.[2] The wax consists of terminal fragments of the original and intermediate species which have been decomposed to a vaporizable size. They contain the altered chain units, created by transfer and disproportionation. Hence one obtains the following approximate relation between r, the molar ratio between

Cryoscopic determinations are available only for ethylene, styrene, and isobutylene; as for the substituted styrenes, it was assumed that the wax has the same average degree of polymerization as in styrene.

There is a great variation in the ϵ (hence also the σ) values. This is what causes the different behavior on degradation, discussed at the beginning. Judging from the results in polymerization, the variations in the termination rates should be minor and the differences primarily due to transfer. The magnitude of the effect is a function of the radical reactivity and the lability of the transferred group. The low monomer yield in polyethylene is thus understandable, as is the effect of CH_3 or *D*-substitution in the main chain. According to

TABLE 1, the ratio between the transfer rates for deuterated and normal styrene should be between 3 and 4. This is somewhat higher than expected for temperatures of about 620°K. However the r, and hence ϵ, values are of limited accuracy and slight changes can exchange the ratio.

Next we consider the rate equations resulting from equation 1 and the molecular weight and rates during conversion. If R denotes the steady state radical concentration, Q_i the sum of the concentrations of molecules of lengths i and $i+1$, and $\tau = k_1 t$, one has:[10, 11]

Random initiation:

$$\frac{dQ_n}{d\tau} = -(1+\sigma)(n-3)Q_n + 2(K_0 - \sigma/4)Q_{n+2} + 2\sum_{i=1}^{\frac{(N-n-2)}{2}} K_i Q_{n+2i+2}; \quad 4 \leq n \leq N-3, \; n \text{ even}$$

$$\frac{dQ_{N-1}}{d\tau} = -(1+\sigma)(N-4)Q_{N-1};$$

$$K_i = (2+\sigma)\left[1 - \left(1 - \frac{3}{4}\epsilon\right)(1-\epsilon)^i\right] + \sigma \qquad (2)$$

Terminal initiation:

$$\frac{dQ_n}{d\tau} = -[2+\sigma(n-3)]Q_n + 2(K_0 - \sigma/4)Q_{n+2} + 2\sum_{i=1}^{\frac{(N-n-2)}{2}} K_i Q_{n+2i+2}; \quad 4 \leq n \leq N-3$$

$$\frac{dQ_{N-1}}{d\tau} = -[2+(N-4)\sigma]Q_{N-1}$$

$$K_i = \sigma[1 - (1 - 3/4\epsilon)(1-\epsilon)^i] + \sigma + \epsilon(1-\epsilon)^i$$

Equation 3 represents an apparent step reaction. The formation of a size n from larger ones is governed by apparent rate constants K_i. In these, the additive term σ indicates the random transfer contribution. The remaining terms show a dependence on i, the position in the chain. If initiation occurs at random, or transfer predominates, bonds in the interior are more vulnerable than those at the periphery; if the zip starts at the periphery, the interior is less likely to be reached.

The essential consequences of equation 3 can be seen intuitively without recourse to the solution. If σ is negligible, the critical quantity is the ratio $\epsilon N/2$ between initial D.P. of the polymer and the zip length. When it is very large, the feature of a chain reaction is lost and it degenerates into a step process, which amounts to exclusive breaking of terminal bonds or a random degradation, depending on the locus of initiation. In the former instance the rate remains constant until the end, because the number of chain ends remains constant; and the reaction is of zero order. In random degradation no simple order can be defined. However there is a maximum rate of conversion when the total number of chain ends reaches a maximum. This can be shown to occur at 25 per cent conversion, practically independently of the size of the evaporating fragments. In turn, when the ratio is very small, a radical, once initiated, is completely destroyed. The initiation is the rate determining step, monomer comes off rapidly, and the reaction is practically of the first order. As pointed out already by Grassie and Melville[1], the molecular weight remains practically constant. For intermediate values of

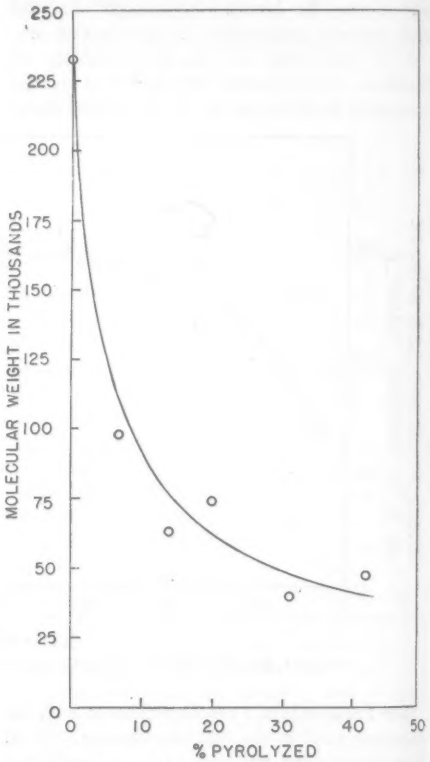

FIGURE 2. Decrease of molecular weight with conversion for polystyrene at 350°C, ref. 12.

$\nu N/2$ and finite σ the picture is modified within the two extremes. In particular, transfer will make for a sharper molecular weight drop. The present discussion indicates the reasons for the observed parallelism between monomer yield Y, molecular weight decrease $-dM/dC$, and overall rate dC/dt; and the connection with the parameters ϵ and σ. Namely:

$$\text{large } 1/\epsilon \rightarrow \text{small } \sigma \rightarrow \text{large } Y \rightarrow \text{small } -dM/dC \rightarrow \text{large } dC/dt. \quad (4)$$

weight curve, FIGURE 2, which is sharp,[12] but does not correspond to random degradation, even if corrected for the evaporation of larger units than monomer. This behavior may be contrasted with that of methyl methacrylate, examined by Grassie and Melville[1], an example of which is shown in FIGURE 3. The numerical evaluation of the solutions of equation 3 necessary for small values of $1/\epsilon$ has not been carried out and hence the lines drawn in FIGURES 1 and 2 were not computed. In FIGURE 3, however, the ϵ-values indicated are

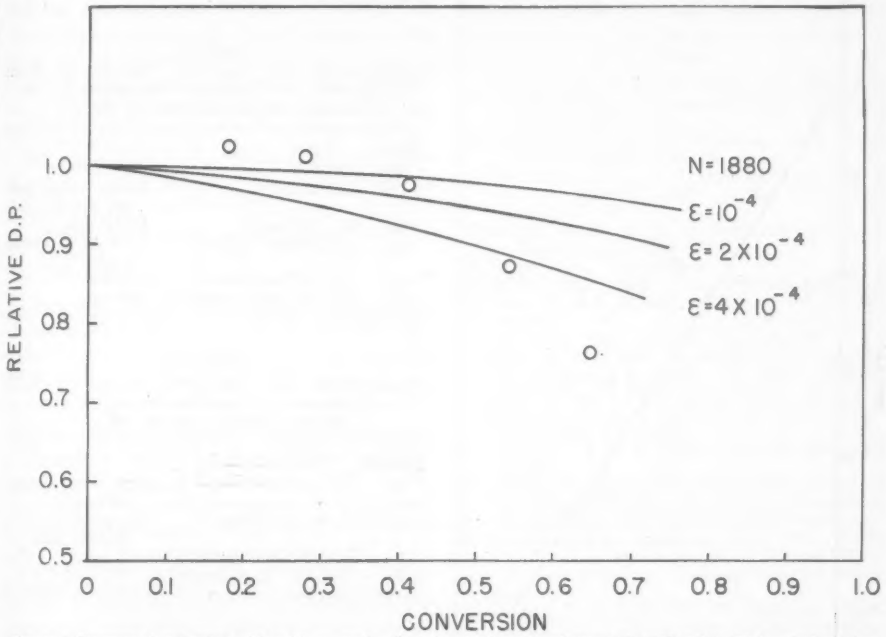

FIGURE 3. Decrease of molecular weight with conversion for polymethyl methacrylate at 220–260°C, ref. 1a. Lines calculated from theory.

This is exemplified by methyl methacrylate. The reverse applies to polyethylene.

Finally, we consider the rate and molecular weight data for styrene and methyl methacrylate in greater detail. FIGURE 1 shows the rate for a sample of the former as a function of conversion, as determined by Madorsky.[12] There is a maximum rate at C $\doteq$ 40 per cent rather than 25 per cent as required by random theory. This is qualitatively understandable in view of the ϵ-value derived which is sufficiently different from unity to make for a chain mechanism. A similar conclusion is reached on the basis of the molecular

derived by fitting theoretical curves to the experimental points. Several experimental as well as theoretical factors caused by molecular inhomogeneities, and/or varying conditions in the system, could be responsible for the deviations at higher conversions.[11] One may also estimate ϵ from the dependence of the initial rate on initial molecular weight. FIGURE 4 shows data of Grassie and Melville.[1] The slight dependence for small D.P. in conjunction with other experiments indicates that the initial break occurs at the chain ends and that the zip length must be large. At higher values of M, there should be a decrease of

the rate, which starts off linearly with $M^{\frac{1}{2}}$. From the slope and intercept, ϵ and k_1 are derived; the former being in agreement with the estimates from molecular weight data.

The following tables summarize the information about the rate constants of the elementary steps and radical concentrations in the pyrolysis and photodegradation of styrene and methyl methacrylate respectively. Without a determination of the mean radical lifetime or of R; k_2, k_3 and k_4 cannot be calculated. However reasonable guesses can be made, at least for k_2. The activation energy is the sum of the heat of polymerization and the energy of the growth step. A preexponential factor of 10^{12}–10^{13}sec^{-1} is characteristic for a monomolecular decomposition reaction. Such a value was actually obtained by Cowley and Melville[13] in their rotating sector studies of the depolymerization of methyl methacrylate. In polystyrene, this order of magnitude is consistent with the ceiling temperature for polymerization.[14] In this polymer σ may be of the order of thousand. It turns out that the adoption of the value for the transfer constant k_3 obtained in

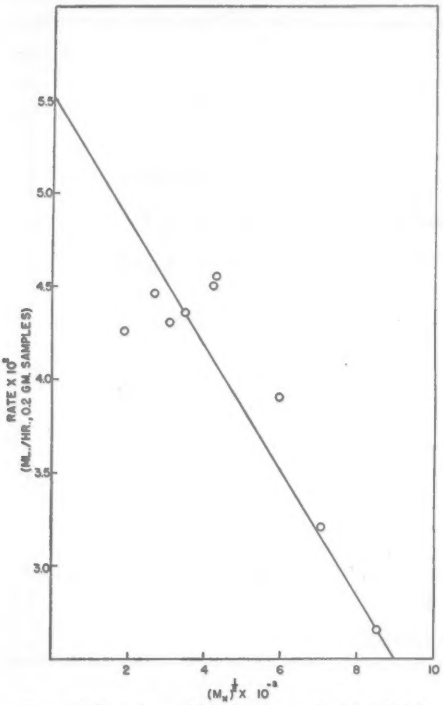

FIGURE 4. Dependence of initial rate on molecular weight for fractions of polymethyl methacrylate computed from ref. 1.

TABLE 1
MONOMER YIELDS AND "ZIP" LENGTHS $1/\epsilon$–1

	Monomer yield, weight (per cent)	$1/\epsilon$
Ethylene	0.025	1.01
Acrylonitrile	1	<1.5
Methyl acrylate	2	<2
Isobutylene	20	4.1
Styrene	40	4.1
p-Methyl styrene	42	4.7*
α-Deuterostyrene	70	12.8*
α-Methyl styrene	>95	>200
Methyl methacrylate	>95	>200

* Estimated from styrene value.

TABLE 2
COMBINATIONS AND ABSOLUTE VALUES OF RATE CONSTANTS IN THERMAL DECOMPOSITION OF METHYL METHACRYLATE, 220–260°C.

Quantity	*Value estimated*	*Source*
$1/\epsilon$	$8.2 \times M^{\frac{1}{2}}$	Initial rate, mol. wt. change
k_1	4×10^{-5}sec^{-1}	Initial rate
k_2	3×10^{4}sec^{-1} (250°C)	$A_2 = 10^{13}$, $E_2 = 18$ kcal
k_4	2×10^{8} l mole^{-1}sec^{-1}	Follows
R	$2 \times 10^{-5} \times M^{-\frac{1}{2}}$ mole l^{-1}	Follows

TABLE 3
COMBINATIONS AND ABSOLUTE VALUES OF RATE CONSTANTS IN PHOTODECOMPOSITION OF METHYL METHACRYLATE, 167°C.[13]

Quantity	*Value estimated*	*Source*
k_1	$1.6 - 4 \times 10^{-6}$sec^{-1}	Mol. wt. change, retarders
k_2	$A_2 = 5 \times 10^{12}$sec^{-1}	k_1, overall rate, radical life time
k_4	4×10^{4} mole^{-1}sec^{-1}	" " "
R	$5 \times 10^{-4} \times M^{-\frac{1}{2}}$ mole l^{-1}	" " "

TABLE 4
COMBINATIONS AND ABSOLUTE VALUES OF RATE CONSTANTS IN THERMAL DECOMPOSITION OF STYRENE, 350°C.

Quantity	*Value estimated*	*Source*
$1/\epsilon$	4.1	Monomer yield
$k_2 R$	4.5×10^{-6}sec^{-1}	Monomer yield, initial rate
k_2	1×10^{4}sec^{-1}	$A_2 = 10^{13}$, $E_2 = 23$ kcal
k_3	1.5×10^{8} mole^{-1}sec^{-1}	Follows
k_1/k_4	2×10^{-17} mole^{-1}	Follows
R	3×10^{-8} mole l^{-1}	Follows

polymerization for the radical-monomer reaction, leads to reasonable values for k_2. This is unexpected since transfer as introduced here is a two-stage process. However, the removal of H from the polymer may be easier than from the monomer. The values assumed lead to radical concentrations of the order of 10^{-8} mole^{-1}. They are larger by a factor of a hundred than in thermal polymerization. It is questionable whether even these concentrations are high enough for a direct measurement of R, say by magnetic means. Further determinations of radical lifetimes will yield absolute constants, whose magnitude we have, in part indirectly, estimated here. One can expect further investigations along the lines which have proven so fruitful in connection with free radical polymerization.

We will conclude with a few remarks about the energies of activation for the initial rates of pyrolysis. They are:

Methyl methacrylate	31–47	kcal.	mole^{-1}	[11]
Styrene	58	"	"	[12]
Ethylene	68	"	"	[12]

In the first polymer this represents mainly the energy of the initiation step, at least for molecular weights below 100.000 or so; the value varying with the nature of the chain ends. In polymers prepared with catalysts, it probably equals the dissociation energy of the catalyst fragment-monomer bond. In polystyrene, the activation energy equals $E_1/2 + E_2 - E_4/2$, or $E_1 - E_4 = 70$. Since $E_4 = 3$kcal in polymerization, E_1 approaches the dissociation energy of the C—C bond. In polyethylene the rate is proportional to $k_1(1 + \sigma) \doteq k_1\sigma$ and the energy equals $E_1/2 + E_3 - E_4/2$. E_1 may be equal to 74, the value obtained in the thermal decomposition of ethane and n-hexane in the presence of chain stoppers[9]. Thus in thermally prepared polystyrene and in polyethylene the initial step may be the break of a C—C bond.

One finds in nature other processes which although chemically different, proceed by the two alternative paths discussed, *viz.* almost complete destruction of individual entities and preservation of others on the one hand, and production of intermediate species on the other. Examples are found in the deterioration of textiles, and the enzymatic degradation of proteins and polysaccharides. It would seem also that in these cases one has either the possibilities of terminal *vs.* random step degradation or, as one alternative a slow step followed by a rapid one.

References

1. GRASSIE, N. & H. W. MELVILLE. 1947. *The Labile Molecule*, Discussions of the Faraday Society. p. 378.
1a. GRASSIE, N. & H. W. MELVILLE. 1949. Proc. Roy. Soc. **A199:** 14, 24, 39.
2. MADORSKY, S. L., S. STRAUS, D. THOMPSON & L. WILLIAMSON. 1949. J. Res. Nat. Bur. Stand. **42:** 499.
3. OAKES, W. G. & R. B. RICHARDS. 1949. J. Chem. Soc. (London) 2929.
4. WALL, L. A. Unpublished.
5. SLATER, N. B. 1948. Proc. Roy. Soc. **A194:** 112.
6. SIMHA, R. & L. A. WALL. 1951. J. Polymer Sci. **6:** 39.
7. SIMHA, R. 1941. J. Appl. Phys. **12:** 569.
8. BELL, R. P. 1949. Trans. Farad. Soc. **45:**.946.
9. PARTINGTON, J. R. 1947. *The Labile Molecule*, Discussions of the Faraday Society. p. 11 4.
10. SIMHA, R., L. A. WALL & P. J. BLATZ. 1950 J. Polymer Sci. **5:** 615.
11. SIMHA, R. & L. A. WALL. J. Phys. Chem., in press.
11a. SIMHA, R. Sept. 24–26, 1951. Paper presented at the Symposium on Polymer Degradation Mechanisms. National Bureau of Standards.
12. MADORSKY, S. L. September 24–26, 1951. Paper presented at the Symposium on Polymer Degradation Mechanisms. National Bureau of Standards.
13. COWLEY, P. R. E. J. & H. W. MELVILLE. Sept. 24–26, 1951. Paper presented at the Symposium on Polymer Degradation Mechanisms. National Bureau of Standards.
14. DAINTON, F. S. & K. J. IVIN. 1948. Nature **162:** 705.

SECTION OF BIOLOGY

INTRODUCTION TO THE SYMPOSIUM ON BACTERIAL PYROGENS*

By FLORENCE B. SEIBERT†

In introducing this symposium, my viewpoint is essentially an historical one. With the increasing use of intravenous therapy, the problem of the pyrogen has become a very important one. Thirty years ago when Professor Mendel posed me the question of whether or not protein produces fever upon intravenous injection, the suspicion was that it did, as indicated in "Protein Therapy and Non-specific Resistance" by Petersen. There were, however, numerous indications that not all proteins were able to elicit fevers and that substances other than protein, such as Salvarsan,

* This and the two following papers were delivered at a Symposium held by the Section of Biology on January 14, 1952.
† Henry Phipps Institute, University of Pennsylvania, Philadelphia, Pennsylvania.

salt solutions, and even distilled water might produce fever.

The riddle was finally solved by the conclusion that any solution may become pyrogenic by reason of contamination with bacterial products, and that some component from the contaminating bacteria is responsible for the fever, not the protein or other substance itself. Moreover, certain types of bacteria, mainly the gram-negative bacteria, were believed to yield this pyrogenic material in greatest quantity. Especially potent pyrogenic products are capable of producing the gram-negative bacilli of the Coliform, Pseudomonas and Salmonella groups. Varying degrees of fever and even distinct types, such as those with a prompt or a delayed rise, or even a double-peak rise, have been described, suggesting the possibility that different pyrogens exist.

With the realization that bacterial contamination of solutions was responsible in many cases for their pyrogenic properties, the practical problem of preparing proper solutions for intravenous therapy was simplified. The importance of using an adequate baffle system in the preparation of distilled water to be used for intravenous solutions was evident, and by this means pure water can now be obtained by a single distillation, instead of by the accepted triple distillation method. As a result, intravenous therapy is widely used.

However, the mere usage of a proven, non-pyrogenic solvent with a test substance will not warrant the conclusion that the substance is or is not a pyrogen. For example, the protein of the tubercle bacillus in a dosage of one gamma or more was reported by Sabin, Miller, Doan, and Wiseman to cause a temperature rise in normal guinea pigs and rabbits, and even greater rises in tuberculous animals; whereas the polysaccharides had no effect. We have also found that intravenous injection of 5 mgms. of a protein extracted from the tubercle bacillus, or one designated as (C) and isolated from tuberculin, caused a temperature rise of 1°C or less, while the same amount of two other tuberculin proteins of the type designated (A) caused no increase. Five milligrams of two tuberculin polysaccharides caused no temperature rise.

It would, therefore, seem to be conclusive that the purified polysaccharides of the tubercle bacillus or of tuberculin are not pyrogens. On the other hand, although the proteins of bacillary bodies and certain ones from tuberculin do cause fever, it cannot be claimed that these proteins are true pyrogens, for in the case of none of these preparations is there evidence that all precautions were taken to assure the absence of foreign pyrogen at every stage of their isolation. Unless this is done, the pyrogenic nature of the product may be due to a foreign, contaminating bacterial product accidentally introduced at some stage in the preparation, as was verified in the case of casein. Bennett and Beeson pointed out, in an excellent review, some of the prevalent misinterpretations which have resulted because of neglect in considering effects due to such contaminating pyrogens.

Certain properties of the pyrogens, such as their remarkable resistance to heat and their ability to be partially adsorbed by certain filter pads, are well-established and have been useful in their evaluation and elimination. These results suggest an attack with the modern ion exchange technics. Although the character of the true pyrogens has not yet been conclusively recorded in the literature, it has been claimed that some of them are of carbohydrate nature. Whether protein or polypeptides are also involved is still under consideration and it is hoped that some of these questions may be answered by the members of this symposium. The isolation of a truly pure and stable pyrogen having well-defined chemical and biological properties, which could be easily reproduced, would furnish a valuable standard for the evaluation of pyrogen in products for intravenous use. A better knowledge of its exact nature could be helpful in designing methods for either avoiding its presence or for eliminating it when present.

The mechanism of the pyrogenic reaction is also not clearly known. Pyrogens have been reported to cause extensive damage to the capillaries, and it has been suggested that there is a relationship to the Schwartzman reaction and to the necrotizing effect on certain neoplasms. Definite changes in the blood, such as a decrease in blood pressure and leucopenia, followed by leucocytosis, have all been shown to follow the injection of pyrogens. There are reports, too, that a specific tolerance to the effect of certain pyrogens can be obtained by repeated injections, whereas none can be demonstrated in the case of pyrogens from other organisms.

The connections between all these phenomena are still not clear, and caution must be used in assigning any of these properties to a pyrogen, *per se*, before all accompanying impurities have been removed, and the chemical purity and identity of the pyrogen has been clearly demonstrated. The

different phenomena may be due to the different components present. In fact, there are a number of reports that the fever response in some cases may not always be accompanied by the leucocyte responses and *vice versa*, indicating a possible independence of the two mechanisms.

The leucocyte response must also be considered from its different aspects, *i.e.*, from the standpoint of a direct or an indirect effect. Because of the minute amount of pyrogen often needed to give a reaction, and of the delay in reaction, an indirect mechanism is suggested. It remains to be determined whether or not there is an *in vivo* release of certain substances due to the effect of the pyrogen, similar to those found in exudates by Menkin. However, the effects of different substances, when applied directly to the cells, can be demonstrated to be different by tissue culture methods.

For example, by these technics Miss Angelina Fabrizio and I have been finding that several tuberculin protein fractions have different effects upon the leucocytes, and all of them more than those caused by the polysaccharides. The effects, moreover, differ depending upon whether the cells come from normal, sensitized, or tuberculous animals. In addition to the inhibition of migration of the cells, for example, increased activity, swelling, clumping, and disintegration of the cells are all characteristic for certain sets of conditions. Miss Fabrizio is publishing these results in the American Review of Tuberculosis. As I indicated earlier, whether or not any of these fractions are true pyrogens is still open to question. It is true, however, that those fractions which have caused the clumping of the leucocytes in tissue culture also gave rise to the most marked fever upon intravenous injection. Reactions, moreover, were more marked in tuberculous than in normal animals.

ACTIVITIES OF CERTAIN BACTERIAL POLYSACCHARIDES*†

By W. F. WINDLE‡

We are studying the physiological activities of certain highly purified bacterial products which are complex polysaccharides, free of protein, and prepared in relatively stable colloidal dispersions in saline or lactate buffer solutions. Although extracts of a number of saprophytic organisms have been used, most of our work has been with one called Pyromen®, which is derived from a *Pseudomonas* species. We have had somewhat less experience with a similar extract of *Proteus vulgaris*. These polysaccharides are of low toxicity, the LD_{50} in mice being about 60,000 micrograms per kilogram of body weight.

Febrile response was the measuring stick employed in our earlier studies, but this has been discarded, for the most part, as we have learned more about other activities unrelated to fever. The use of pyrogenic doses of these polysaccharides introduces factors which can be avoided with subfebrile amounts. Our present measure of activity, which shall be designated as the "minimal Pyromen response," is a rise in number of circulating leucocytes, probably the neutrophils. This appears two to three hours, and subsides four to six hours, after intravenous administration. It is sometimes preceded by leucopenia 15 to 45 minutes after giving the drug. The leucocytosis can be completely dissociated from the leucopenia as well as the fever.

The minimal Pyromen response has been elicited in most human subjects with less than 0.05 microgram of Pyromen per kilogram of body weight administered intravenously. Usually ten times this amount has been given to laboratory animals (mice, rats, guinea pigs, rabbits, cats, dogs, or monkeys). Human subjects exhibit greater variability in respect to the minimum required dose than do most animals. Variations in response may be related to the state of endocrine activity, as borne out in clinical experience.

A somewhat different response has often been encountered in laboratory animals after intravenous doses of 1 to 5 micrograms per kilogram of body weight, and has been observed occasionally in human subjects receiving as little as 0.03 micrograms per kilogram; usually somewhat more than 0.05 microgram per kilogram being required. The response is characterized by a marked leucopenia phase like that following intravenous administration of adrenalin, and the subsequent leucocytosis is often less marked than that obtained

* The second paper in the Symposium, delivered by David M. Tennent, had not been received at the time of publication.

† Studies on which this paper is based are being conducted by E. G. Stuart, C. D. Clemente, S. Q. Mitchell, L. C. Greene, Donald Scott, Jr., W. W. Chambers, and Jae L. Littrell. Many of the results have not been published in detail.

‡ Baxter Laboratories, Inc., Morton Grove, Ill., and the University of Pennsylvania, Philadelphia, Pa.

with low doses. The leucocytosis is accompanied by a depression in number of circulating lymphocytes and eosinophils, and a rise in body temperature (0.6 to 1.6°F). Chills, headache, and myalgia have been experienced by a few human subjects. Leucopenia in the cat is accompanied by a rise in the plasma ascorbic acid level, with depletion occurring during the leucocytosis.

The total leucocyte count may rise 50–100 *per cent* above the initial level during the peak of a minimal Pyromen response. It is possible to superimpose one response upon another and reach a phenomenal degree of leucocytosis. For example, a cat which exhibited the minimal response after receiving 0.05 microgram per kilogram intravenously was given a like amount of Pyromen every time a half-hourly white count revealed that the peak of the leucocyte rise had been passed. By the end of 30 hours, the number of leucocytes had risen from 13,000 to 67,000 per cmm. Continuous presentation of the drug by subcutaneous injections every 15 minutes, and presentation during the rising phase of the leucocytosis, failed to enhance the leucocytosis. In fact, the latter procedure usually brought the count down.

Acute histological changes appear to have resulted from such a procedure as the above. These are hyperplasia of thymus, lymph nodules, and splenic corpuscles; depletion of the lymphocyte population of peribronchial tissue and of the tumica propria of the intestines; depletion of cytoplasmic droplets of the adrenal fascicular zone, and of thyroid follicular colloid; with no marked changes in other organs (bone marrow not yet studied).

Histological changes observed in cats and rabbits treated daily (or three times weekly for 10 to 120 days) with a polysaccharide from *Proteus vulgaris* in subfebrile as well as in febrile doses of great magnitude were: hyperplasia of all lymphoid tissues; hyperplasia and increased phagocytosis in the reticulo-endothelial system; metaplasia in spleen and liver with extramedullary hemopoiesis; hyperplasia of the adrenal reticular zone at the expense of the zona fasciculata; and certain changes in other endocrine organs. Some of the histological preparations are suggestive of rejuvenation, or reversion to the fetal state. There was no evidence of the type of pathology seen in true stress.

These and other studies have suggested that activities of bacterial polysaccharides involve endocrine mechanisms. Chronic bilateral adrenalectomy in cats abolished the minimal Pyromen response except for a slight leucopenia, but subsequent transplantation of adrenal cortical tissue revived the response. Febrile doses of 100 to 200 micrograms of this drug killed adrenalectomized cats, whereas intact cats showed only mildly toxic symptoms after receiving 1,000 micrograms or more.

After hypophysectomy, the cat's minimal Pyromen response was altered in degree. The leucocytosis was present, but slight; leucopenia occurred and was accompanied by fever; as the white count went down the temperature rose.

Thyroidectomy altered the minimal Pyromen response in respect to time; the leucopenia not appearing until three hours after the drug had been administered, and the leucocytosis only after nine hours. Ovarectomy gave a somewhat similar picture. Oestrus, pregnancy and lactation were accompanied by variations in the minimal Pyromen response.

We are still trying to clarify the relationship between bacterial polysaccharide activities, the endocrine system, and connective tissue. We believe that the adrenal may play an important part in the minimal Pyromen response, but in a manner dissimilar to its role in stress. The effects of subfebrile doses of bacterial polysaccharides are unlike those produced by the administration of cortisone. Notable in that they are opposite to the effects of cortisone are the hyperplasia of thymus, stimulation of lymphoid tissues, and exacerbation of the Arthus phenomenon with elevation of antibody titre in rabbits sensitized with egg albumen nitrogen.

Inflammation and healing processes of injured connective tissue are enhanced by administration of Pyromen in cats, guinea pigs, and rats. Skin burns, which were lethal to untreated rats in six to twelve hours, were nonlethal in animals receiving daily doses which normally elicit the minimal Pyromen response; but no protective effect was obtained with lower or higher doses of the drug. Healing of spot burns in cats given the bacterial polysaccharide occurred about 15 days earlier than in untreated animals, and with less edema, greater vascularization, and natural debridement of dead tissue. Histological study revealed a richer bed of granulation tissue than in untreated stressed animals. It seems that enhancement of permeability of the connective tissue played an important part in this strikingly beneficial effect; indeed, that local rejuvenation had taken place.

Among the many interesting activities of bacterial polysaccharides, their influence on the healing of brain and spinal cord wounds is perhaps the most dramatic. When the spinal cord of the cat is transected, a fibrous and glial scar forms promptly; a scar formation which may be enhanced by the stress of trauma. At any rate, it very effectively blocks any attempt on the part of severed neurons to regenerate across the site of the transection. Therapy with Pyromen altered this situation, especially when the severed ends were closely approximated. No glial barrier formed, but relatively undifferentiated connective tissue cells, *i.e.*, reticular tissue cells and macrophages, came to fill the traumatized region. Sprouting fibers from the severed spinal cord neurons traversed the transection site along the processes of these primitive cells much as regenerating peripheral nerve fibers follow neurolemma cells. Neuronal regeneration is a slow process, and we have not yet learned how to control it completely, but there has been limited success in obtaining functional recovery. Electrophysiological studies have clearly demonstrated that there is conduction through the transection site.

The importance of preventing glial barrier formation in central neuronal regeneration can best be illustrated by some recent experiments. The central stump of the severed temporal branch of the cat's facial nerve was implanted into its temporal cortex. In untreated control animals, the peripheral neuroma was walled off from brain tissue by a prominent glial barrier in a month's time. Other operated cats were treated with Pyromen, and in 30 to 35 days there was marked blending of peripheral neurons with the brain parenchyma. A similarly operated rabbit treated with ACTH showed some blending, but cats given cortisone were like the untreated controls.

BIOLOGY OF PYROGENS*

By PAUL A. ZAHL AND S. H. HUTNER†

Introduction. Both gram-negative and gram-positive bacteria elaborate pyrogens, but the commonest and most potent pyrogens appear to be associated with the somatic antigens of the gram-negatives.[1, 2] These somatic antigens have a manifold toxicity, including: (1) hemorrhage-induction in implanted sarcomas; (2) interference with the homoiothermic system, *i.e.*, hypothermia in rats, mice, and guinea pigs, and hyperthermia in rabbits and man; (3) vascular damage in deciduaplacental tissues; (4) marked antigenic activity; (5) induction of leukopenia, hyperglycemia, and adrenal cortical damage; and (6) general systemic toxicity.[3] All immunochemical work to date indicates that pyrogenicity, at least as associated with gram-negative bacteria, represents but one aspect of poisoning by endotoxins.

Immunochemists studying these poisonous antigens, while noting, in passing, their pyrogenicity, seem generally to have ignored the pyrogenic effect as such; and workers interested in pyrogens primarily as dangerous nuisances in the parenteral administration of therapeutic agents, have neglected to apply much of the pertinent biochemical information. The Sanarelli-Shwartzman phenomenon, another manifestation of the action of the endotoxins of gram-negative bacteria, has also acquired a quasi-independent literature. To add to the confusion, medical microbiologists have not taken full advantage of data from general microbiology in elucidating the genesis and control of pyrogens. Finally, there has been little effort to relate the problem of the specific and general systemic toxicity of pyrogens to the problems of shock and stress now in the forefront of medical interest. This short review attempts an interweaving of some of these artificially separated strands of the pyrogen-endotoxin problem.

Origin of Pyrogens. The possession of endotoxins by most, if not all, gram-negative bacteria is not necessarily related to invasiveness; toxicity here betokens, so to speak, original sin, for it is displayed by phylogenetically primitive photosynthetic and chemosynthetic organisms remote from the parasitic habit.[4] There is no basis for interpreting the widespread possession of endotoxins by gram-negative bacteria as a portent that free-living species have any exceptional tendency to become pathogens.

Some of the mystery surrounding the colonization of distilled water by bacteria, with a resulting

* This paper was presented by the second author at the meeting of the Section on January 14, 1952.
† The Haskins Laboratories, 305 E. 43rd Street, New York 17, N. Y.

pyrogenicity of the water, is rendered less opaque if two principles of comparative microbiology are applied: (1) any reaction liberating energy can be exploited by some living organism as a source of energy[5]; and (2) from experience with non-parasitic bacteria: "practically any type of micro-organism can be isolated from any inoculum, provided that this is applied in a large enough quantity and that the culture method is sufficiently specific."[6]

There are many opportunities for bacteria to become established in distilled water maintained under laboratory conditions. Photosynthetic bacteria which can use infra-red as well as visible light are ubiquitous, and at least some of them fix atmospheric nitrogen. The hydrogen donor they require may come from H_2S, or traces of organic acids or alcohols in the atmosphere. H_2S is also attacked by equally ubiquitous species of *Thiobacillus*. Where illuminating gas escapes into laboratory atmospheres, the hydrocarbons and CO can likewise support microbial populations; if animal quarters are nearby, nitrifying bacteria can flourish on the liberated ammonia.

The following anecdote illustrates how more remote opportunities for bacterial growth are created. Two enterprising workers in Professor van Niel's laboratory, seeking to isolate bacteria capable of using electrical energy directly, inserted the terminals of a battery into a beaker of water containing a pinch of soil as inoculum. In a few hours, a cloud of bacteria appeared at the negative terminal. These bacteria were not, of course, motors incarnate; they were, instead, hydrogen bacteria fixing CO_2 with the energy gained by oxidizing the H_2 liberated by electrolysis. Many heterotrophic pseudomonads also function as hydrogen bacteria, pseudomonads as a group being liberally endowed with pyrogens. The film of H_2 which forms on wet particles of steel[7] may therefore support a population of pyrogenic bacteria.

On occasion, the primary micro-flora may not be composed of gram-negative bacteria. However, in view of the ubiquity and efficiency of heterotrophic gram-negative bacteria as scavengers, a secondary micro-flora with an appreciable representation of gram-negatives is likely to appear. Frequently this is observed in enrichment cultures with various substrates.

Avoidance of Pyrogenic Contaminants. What kind of control measures are required to avoid growth of pyrogens? Prevention is better than cure, for these endotoxins are thermostable and persistent. In work on vitamins as microbial growth factors, it has been found helpful (indeed almost indispensable) to protect both inorganic and organic solutions with a drop or two of a water-immiscible volatile preservative consisting of (by volume) 1 part chlorobenzene, 1 part 1,2-dichloroethane, and 2 parts *n*-butyl chloride. This preservative is volatilized away on autoclaving or distillation under reduced pressure.[8] For thermolabile materials, sterilization by means of non-inflammable ethylene oxide-CO_2 mixtures appears promising. For storage of distilled water, the large polyethylene containers now available seem to offer advantages over glass, as polyethylene is inert, and unlike glass, has no nutrient salts to be leached out. Polyethylene or other plastic tubing would, likewise, be preferable to glass or rubber tubing.

There is room for improvement in commercial water stills. Rather than the 3-stage distillation traditionally favored by hospitals, it would seem worth while in these days of mounting fuel costs to copy industrial practice and design a really efficient splash-trap; one amply able to intercept entrained bacterial bodies. Furthermore, the use of a condenser, spray-coated or otherwise fabricated with the thermostable polyfluorotoluene, would help eliminate the entrance of micronutrient metal ions, and so provide less support for microbial growth.

Chemistry and Mode of Action of Pyrogens. Tal and Goebel have made some penetrating studies into the composition of the endotoxins of gram-negative bacteria.[9] The procedure in dissecting out the toxic principle resembles the peeling of a large, delicate, multilayered onion. A tiny nub at the center of the onion would be the toxic principle. It has been thoroughly established that the negative endotoxin consists of phospholipid and polysaccharide which mask a protein or polypeptide. The phospholipid, and much of the protein and polysaccharide as well, is removable, and toxicity may depend on phosphate groups attached to the polysaccharide and, less certainly (perhaps under some conditions of purification) to the "protein" component. Since virtually all toxicity exerted by non-corrosive organic compounds today is interpreted as dis-

placement of one or another essential metabolite in the cell, the consideration of the pyrogenic endotoxin as an anti-metabolite would open up interesting biochemical possibilities.

Little can be said with surety about what is the primary target of the toxin. The hyperthermia (in rabbits and man) or hypothermia (in rats, mice, and guinea pigs)[1, 3] induced in the intact animal suggest a special action on the thermoregulatory center, presumably in the hypothalamus. That the endotoxin does not injure isolated cells has been clearly demonstrated by the fact that suspensions of tumor cells are unimpaired in viability when exposed to the endotoxin, while solid tumor implants show hemorrhage.[3, 10] The endotoxins of nearly all gram-negative bacteria have been shown repeatedly to induce capillary damage in sarcoma implants, as well as in the decidua-placental tissues of mice and rabbits.[11, 12, 13] The tacit assumption is that the primary target of the endotoxin, in these regards, are the epithelial cells of newly-proliferated capillaries. An absolute test of this assumption remains to be made.

In an extensive empirical study of the pharmacological treatment of poisoning by *Salmonella* endotoxin, the only agents showing therapeutic activity were thyroid antagonists, *i.e.*, goitrogens such as the sulfa drugs and thiouracil;[14] penicillin, although not a goitrogen, has a similar action.[15] But all these are of limited effectiveness. It would be desirable to pursue this line of attack, especially now that the problem of shock is in clearer focus, and that such new drugs as potent adrenolytic agents are available. Protection by active immunization, however, does not seem a particularly profitable line of investigation: while anti-infectious immunity is easily induced, antitoxic protection is rather limited.[16, 17] Apparently, the explanation lies in the fact that the combination of antigen and antibody is still toxic. A counterpart of this phenomenon is that enzymes retain their activity even when precipitated by homologous antibody. The observed diminution of enzymatic activity is probably explicable on the basis of a change in the physical state of aggregation of the enzyme.[18]

By way of brief conclusion we should like to recall Pascal's belief that truth is more likely to arise from error than from confusion.

Bibliography

1. Olitsky, L., S. Averiny, & P. K. Koch. 1942. The hypothermic and adreno-hemorrhagic effects of bacterial vaccines. J. Immunol. **45:** 237.
2. Zahl, P. A. & S. H. Hutner. 1944. Temperature factors in the action of certain bacterial endotoxins. Proc. Soc. Exp. Biol. & Med. **56:** 156.
3. Zahl, P. A. 1950. Action of bacterial toxins on tumors. VIII. Factors in their use for cancer therapy. J. Nat. Cancer Inst. **11:** 279.
4. Zahl, P. A., M. P. Starr, & S. H. Hutner. 1945. Action of bacterial toxins on tumors. VII. The tumor-hemorrhage factor in bacteria. Amer. J. Hyg. **41:** 41.
5. Van Niel, C. B. 1940. The biochemistry of microorganisms; an approach to general and comparative biochemistry. Pub. Am. Assoc. Advance. Sci. **14:** 106.
6. Van Niel, C. B. 1931. On the morphology and physiology of the purple and green sulphur bacteria. Arch. Mikrobiol. **3:** 1.
7. Butlin, K. R. & M. E. Adams. 1947. Autotrophic growth of sulphate-reducing bacteria. Nature, London. **160:** 154.
8. Hutner, S. H. & L. Provasoli. 1951. The phytoflagellates. In Biochemistry and Physiology of Protozoa, A. Lwoff, Ed. Academic Press, N. Y.
9. Tal, C. & W. F. Goebel. 1950. On the nature of the toxic component of the somatic antigen on *Shigella paradysenteriae*, type Z (Flexner). J. Exp. Med. **92:** 25.
10. Klein, G. 1951. The production of ascites tumors in mice and their use in studies on some biological and chemical characteristics of neoplastic cells. Uppsala, Almquist, & Wikells, p. 33.
11. Zahl, P. A., S. H. Hutner, S. Spitz, K. Sugiura & F. S. Cooper. 1942. Action of bacterial toxins on tumors. I. Relationship of the tumor-hemorrhagic agent to the endotoxin antigen of gram-negative bacteria. Amer. J. Hyg. **36:** 224.
12. Zahl, P. A. & C. Bjerknes. 1944. Effect of the endotoxin of *Shigella paradysenteriae* on pregnancy in rabbits. Proc. Soc. Exp. Biol. & Med. **56:** 153.
13. Zahl, P. A. & C. Bjerknes. 1943. Induction of deciduaplacental hemorrhage in mice by the endotoxins of certain gram-negative bacteria. Proc. Soc. Exp. Biol. & Med. **54:** 329.
14. Zahl, P. A., M. L. Drasher, &. S. H. Hutner. 1946. Pharmacological protection against Salmonella endotoxin and certain other poisons. Proc. Soc. Exp. Biol. & Med. **63:** 550.
15. Boor, A. K. & C. P. Miller. 1945. The effect of penicillin on the lethal action of meningococcal endotoxin in experimental animals. Sciences, **102:** 427.
16. Burrows, W. 1951. Endotoxins. Ann. Rev. Microbiol. **5:** 181.
17. Zahl, P. A., S. H. Hutner, &. F. S. Cooper. 1943. Action of bacterial toxins on tumors. V. Immunological protection against tumor hemorrhage. Proc. Soc. Exp. Biol. & Med. **54:** 48.
18. Sumner, J. B. 1951. Chap. "Urease" in: The Enzymes, Ed. J. B. Sumner and K. Myrbäck. Academic Press, N. Y.

STREPTOCOCCAL HYALURONIDASE*†

By KARL MEYER‡

Enzymes depolymerizing hyaluronic acid have been reported present in many strains of various streptococci groups, especially those strains belonging to groups A, B and C.[1] While many mucoid and non-mucoid strains may produce hyaluronidase in low concentrations, however, good hyaluronidase producers are infrequent.[2] The influence of hyaluronic acid and its hydrolysates on the enzyme production of a group C strain has been studied by Rogers,[3] and of group A strains by Crowley.[4] Our laboratory has studied the enzyme of one group A strain (H44) and of one group C strain, the latter in the form of either commercial preparations of "streptodornase" or fractions supplied to us by the Lederle Company.[5] Apparently, the enzyme is concentrated in streptodornase fractions, and only slightly in the streptokinase fraction. In three different commercial samples of the mixed enzymes, activities of 30, 40, and 150 TRU per mg of protein were found.

The reaction of streptococcal hyaluronidase is very similar to that of the pneumococcal[6] and staphylococcal enzymes, and is markedly different from that of the testicular enzyme. First, testicular hyaluronidase has a high affinity for hyaluronic acid of high molecular weight. This affinity rapidly decreases as the molecular weight of the substrate decreases, *i.e.*, the enzyme acts as a true depolymerase. In contrast, the affinity of bacterial enzymes toward the substrate is nearly independent of the molecular weight of the split products. Second, with testicular hyaluronidase, the end products of the enzymatic hydrolysis consist of mixed oligosaccharides, mainly tetrasaccharide and higher units. With the bacterial enzymes, the end product appears to be a disaccharide; a similar product being obtained when the bacterial enzymes act on the oligosaccharide end products of the testicular enzyme. The disaccharide, however, has properties different from those obtained from hyaluronic acid by other procedures,[7, 8] and may have been modified from the constituent disaccharide of the original polysaccharide. Third, bacterial hyaluronidases are further distinct from the testicular enzyme in their far greater heat lability. At pH 5 the activity of testicular hyaluronidase at 60° is only 7 per cent* less than its activity at 37°, while under the same conditions pneumococcal hyaluronidase is inactivated.[5]

Bacterial, as well as testicular, hyaluronidases attack only hexosaminidic bonds and leave the glucuronidic bonds intact. Crude testicular extracts contain a β-glucuronidase which hydrolyses the glucuronidic linkages of the oligosaccharides but apparently only when these are located terminally. The β-glucuronidase is absent in the examined crude pneumococcal and streptococcal extracts. Centrally located glucosaminidic bonds appear to be preferentially hydrolysed by both types of hyaluronidases.

A considerable literature has accumulated on anti-hyaluronidases which are group specific for hemolytic streptococci.[8] Apparently, group specific inhibitors appear quite regularly and early in group A infections. This implies either that the enzyme is an exceptionally effective antigen or, more likely, that the inhibitor is a cross-specific antibody against some streptococcal protein.

Bacterial hyaluronidases probably play a predominantly metabolic role and bear little relationship to infectivity and infection. It will be interesting to study the metabolism of hydrolysis products of hyaluronic acid in the organisms in relation to their production of hyaluronidases.

Bibliography

1. Russell, B. E., & N. P. Sherwood. 1949. J. Infect. Dis. **84:** 81.
2. Sallman, B., & M. Birkeland. 1950. Ann. N. Y. Acad. Sci. **52:** 1062.
3. Rogers, H. J. 1946. Bioch. J. **40:** 583.
4. Crowley, N. 1951. J. Gen. Microbiol. **5:** 239.
5. Unpublished experiments.
6. Rapport, M. M., A. Linker, & K. Meyer. 1951. J.B.C. **192:** 283.
7. Meyer, K., A. Linker, & M. M. Rapport. 1951. J.B.C. **192:** 275.
8. Wenner, H. A., D. M. Gibson, & R. Jacques. 1951. Proc. Soc. Exp. Biol. & Med. **76:** 585.

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‡ Department of Medicine, College of Physicians and Surgeons, Columbia University, New York, N. Y.

* Testicular hyaluronidase is a remarkably heat-stable enzyme. Heating for 5 minutes to 100° inactivates the enzyme only to the extent of 85 per cent. The temperature optimum of the testicular enzyme at pH 5 is 55°. At pH 4 and 3, the activity at 60° is only 52 and 85 per cent, respectively, of the activity at 37°. All activities were determined turbidimetrically.

SECTION OF MATHEMATICS AND ENGINEERING

INFLUENCE OF AN ELECTRIC FIELD ON AN ELECTRIC CURRENT IN METALLIC OR CARBON CONDUCTORS*

By OLEG YADOFF†

State of the Problem. Ever since the discovery of electricity the nature of the electric current in conductors has attracted the attention of scientists. Whereas questions dealing with the conductivity of metals have been interpreted in a relatively clear and concrete manner, the nature of the electric current still remains obscure; for scientists have not yet been able to determine the real physical nature of the electric current.

It is definitely known that the electric current in metallic conductors consists of a flow of electrons, *i.e.*, elementary negative charges; protons, the elementary positive charges, playing no active role in the current. The electronic theory of H. A. Lorentz was the first capable of providing a physical representation of the electric current, but it soon encountered particular problems which it was never able to solve. It is worth mentioning that this representation of the electric current was attempted by scientists such as J. J. Thomson, Poyting, and Rikke, reaching its climax in the works of P. Drude. Among the more contemporary authors were F. Bloch, Nordheim, R. Peierls, Wilson, and Frenkel, with especially notable theories of conductivity by Professor P. W. Bridgman.

On our part, we were successful in representing the nature of the electric current in terms of the modern concepts of physics. On the basis of our hypothesis, the electric current consists of electronic waves passing within a conductor, and of their interaction with matter. Such interaction can take place between the moving electronic waves and the vibrating thermal waves of the atomic network of the conductor. A picture of the interferences between these waves of completely different natures is definitely possible; the interaction resembling the well-known phenomenon of optical interference. The electronic waves explain the formation of the whirling magnetic field around the electric current, far better than any other known representation of the nature of the current.

We cannot at present study this question in more detail, for the topic of our paper is different. We should like to point out, however, that the practical conclusions which will be drawn at the end of the paper, concerning the influence of the electric field on the electric current in metallic conductors, will appear more real and more sound if the current is really formed by rapidly moving electronic waves, and not by the summation of separate electrons jumping from one metallic atom to another. Those who may wish to acquaint themselves more thoroughly with our hypothesis can consult our lecture delivered to the International Conference of the Great High Tension Electric Networks.*

It is also worth remembering Maxwell's opinion on the nature of the electric current. In his conclusion, Maxwell admits that the electric current still remains an unsolved riddle for scientists. The speed at which any one elementary electric charge travels can be very small or extremely great; and can equally well be a tenth of an inch per hour or some hundreds of thousands of miles per second. The first case tends to justify the theory that an electron moves from atom to atom, while in the second case it is easier to visualize the theory of rapidly moving electronic waves.

Although favoring the second of these theories, we should like to emphasize that interest in the study of the influence of an electric field on the electric current is in no way decreased by any other theory on the nature of the electric current. The only important factor is that the electric current is formed by the flow of electrons and the accompanying magnetic field.

It is known that the conductivity of any given metallic conductor varies according to certain physical factors. It is primarily known that the conductivity varies with changes in temperature. In the field of high and average temperatures, going up to 200 absolute degrees, the conductivity

* This paper was presented at a meeting of the Section on January 18, 1952.

† Department of Civil Engineering, Columbia University, New York, N. Y.

* (Conference Internationale des Grands Resaux Electriques a Haute Tension—Report No. 326. "On the Nature of the Electric Current According to the Conception of Contemporary Theories." Paris, Session 1946.)

is inversely proportional to the temperature $\left(C = \frac{K}{T}\right)$, where C is electric conductivity, K an arbitrary constant, and T is absolute temperature. In the case of lower temperatures, the changes in the conductivity vary inversely as the temperature to the fourth power $\left(C = \frac{K}{T^4}\right)$. The latest low temperature experiments of Gruneitzen show changes in conductivity from temperatures in the fifth power $\left(C = \frac{K}{T^5}\right)$. It is apparent that a scale of several functions exists in the interval of temperatures between T and T^5. The different aspects of the laws can be explained easily by the conditions of quantic mechanics, but this topic is beyond the scope of our report.

In a study of those exterior factors which influence changes in conductivity, we must note Bridgman's theory which maintains that conductivity increases depending upon pressure from outside.

An interesting example is the change in conductivity under the influence of a magnetic field [$C = f(H)$]. The conductivity of any metallic conductor will change if the latter is placed in a magnetic field H whose direction is perpendicular to the conductor. The conductivity C_0, in the absence of a magnetic field, acquires the dimension C_1 when it is placed within a magnetic field. The increase $\Delta C = C_1 - C_0$, is a function of the magnetic field H. This function, $C = f(H)$, was determined by Kapitza up to 320,000 gauss; and the magnetic field applied for one one-hundredth of a second. The characteristic of the curve denoting $C = f(H)$ is the same for all the metals: a parabolic section extended by a straight line (first $C = KH^2$, and later $C = KH$).

The influence, under certain conditions, of electro-magnetic waves (the basis of the whole technique of telecommunications), or the influence of the light effects (photoelectric effect) upon the conductivity of metals is well known to us.

It is quite understandable that the question of the influence of an electric field on an electric current in metallic conductors has a scientific as well as a practical interest. Below we give an example of the influence of an electric field on an electric conductor placed along the axis of a cylindrical body; radially concentric lines of force of an electric field E are directed towards the conductor from the inner walls of this cylinder. The following are the data of this example.

Experimental Arrangement. FIGURE 1 shows the device of the experiment. We place a metallic conductor F within a metallic cylindrical body C whose walls are made out of a screen; the apparatus so arranged that there is no electrical or mechanical contact between the inner walls of the cylinder C and the conductor F. We find only air under normal atmospheric pressure between the inner walls of cylinder C and conductor F.

Conductor F is charged with an electric current of any intensity i, by means of a battery or any other source of electricity (any distributor of a direct or alternating current can be used for this

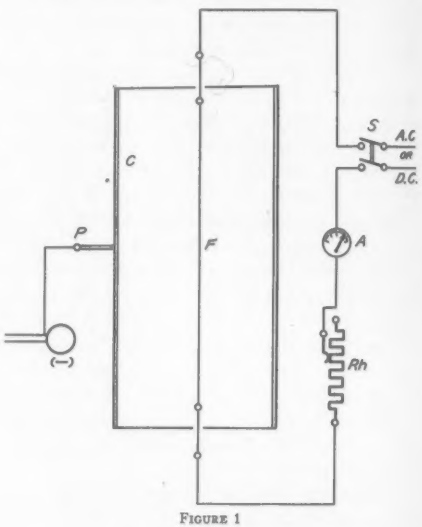


FIGURE 1

purpose). The desired intensity of current i is regulated by a rheostat, Rh, and an amperemeter, A. Having attained the desired intensity of current, we apply to cylinder C through contact P one of the poles of an electrostatic generator or of a source of direct current. The voltage of such a source is determined by the necessity of obtaining an electric field E whose intensity is not smaller than one kilovolt per centimeter along the radius separating the conductor from the inner wall of the cylinder. It follows, therefore, that the source generating the electric field within the cylinder must have a relatively high voltage. The second pole of this source is not used in the process. It can either be completely lacking (as in the case of an electrostatic generator), or it can be grounded.

The electric field E is created by a certain difference in potentials between the inner wall of cylinder C and conductor F. This is not a classical potential difference of a closed electric circuit, but a particular potential difference between one electric system and another. In addition, both of these systems are not only independent of one another, but can be of completely different electric natures. For example, conductor F is charged by an alternating current of 110 volts, while cylinder C is charged by negative or positive electrostatic charges of 15 kV.

As soon as the high voltage contact P is applied from the outside to the cylinder, the electric field E is formed, and we notice a change in the conductivity of conductor F. The conductivity increases, and the change is a function of the electric field, $C = \varphi(E)$.

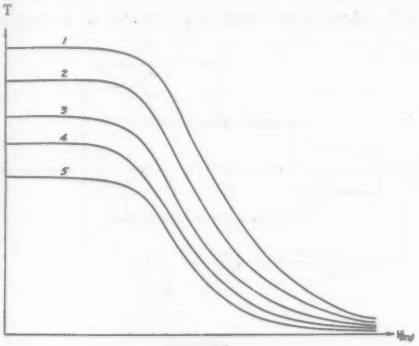


FIGURE 2

The change in the conductivity increases while the electric field E is increasing. The effect of the influence of the electric field, however, is noticed only if the intensity of the latter is higher than a definite intensity E_0. This field E_0 which can be considered the critical point below which the effect of the change in the conductivity cannot be noted, is approximately equal to 1 kV per cm., and is true in all cases regardless of the intensity of current i, and of the type of conductor. It follows, therefore, that the potential of contact P which is applied to cylinder C depends solely upon the size of the apparatus. In other words, it depends upon the radius connecting conductor F with the inner wall of cylinder C.

FIGURE 2 shows the curves which characterize the physical significance of this effect. For greater accuracy it is preferable to consider the functions $t^0 = \psi(E)$, *i.e.*, the variations of the interior temperature of the conductor in function of E. In order to plot these curves, we measure the changes in the resistance R in function of E by means of an accurate apparatus such as the Wheatstone bridge and, by using the known formula $R = R_0(1 + \alpha t^0 + \beta t^{02})$, we calculate temperature t^0, in degrees centigrade, with sufficient accuracy. It might be recalled that the exact meaning of conductance can easily be stated by the expression $C = \frac{1}{R}$. In order to be able to plot each curve, we must perform our experiments with a constant current i. In the above graph, the intensity of current i is an independent parameter. For example, in the case of a conductor one tenth of a millimeter in diameter, consisting of an alloy of Pt (90 per cent) and Ir (10 per cent), whose temperature coefficients are $\alpha = 3.95805 \times 10^{-3}$ and $\beta = 5.805 \times 10^{-7}$, and inserted in an apparatus 5 cm. in radius, we obtain the following data which are characteristic of the effect:

i = 1.50 amp.	t^0C = 940	E_0 =	1.2 kV
id	t^0C = 400	E =	16.5 kV.

The phenomenon of the influence of an electric field on the conductivity of metallic conductors is observed particularly well if the testing conductor is brought to a state of incandescence. As soon as contact P is connected to cylinder C, the state of incandescence vanishes and the conductor acquires the aspects of a cool metal. In a dark room we can observe how the conductor loses its color and becomes unnoticeable under the influence of an electric field. After contact P is disconnected from cylinder C, the conductor returns to its original condition and reassumes the red hot color. It is interesting to note that the "cooling" process of the conductor under the action of the electric field is considerably faster than the return to the original condition after contact P is disconnected. It is not necessary to connect contact P with the center of cylinder C, but it can be applied at any point of the cylinder; the effect will be absolutely the same. It will disappear, however, if contact P i sintroduced into cylinder C without touching it. We get a very insignificant effect in the area surrounding contact P, if the latter is placed relatively close to the conductor.

The effect will occur in highly discharged space only if the applied electric field E is negative.

The effect will disappear if the electric field E is positive. For example, in a vacuum of 10^{-7} mm of Hg, we have approximately 3×10^9 molecules for each cubic centimeter at 0°C. It is true that the number of molecules is still great, but it is very insignificant by comparison with their number under normal pressure: 2.7×10^{19}. The disappearance of the effect in a vacuum with a positive field E is very significant from the point of view of its theoretical appraisal. We must conclude, first of all, that the process of the influence of an electric field on conductance is not quite identical for the negative E as for the positive E. Secondly, and this is most important, we conclude that in such discharged space (3×10^9 molecules per cm^3) we cannot obtain that classical ionization of the medium which permits the formation of convection currents. We know that under these conditions the electrons can be ejected from the electrodes only under the action of an electric field. We shall return to this question later when we discuss our theoretical considerations.

If the electric field E is progressively intensified or decreased, it is then easy to determine field E' under which the Corona effects are formed on the surface of conductor F, or field E'' which forms the space current effects. These designations E' and E'' of the electric field approach critical field E_0, but it is clear that they must be less than E_0. When an electric current i_1 passing through conductor F causes a state of incandescence σ_0, the latter will vanish after the electric field E is connected, while the intensity of the current will change to i_1'. By acting upon the rheostat Rh we can again obtain the state σ_0, but the corresponding current will become i_2. The increase in the intensity of current, $\Delta i = i_2 - i_1$, depends upon E, upon the degree of incandescence σ, and on the nature of the conductor. It can reach from 30 per cent to 40 per cent of the original current. If, when current i_2 is established, field E is suddenly illuminated by disconnecting contact P, we shall create in conductor F a short circuit, so to say, and as a result, the conductor will melt. Consequently, the conductor will conduct from 30 per cent to 40 per cent more electricity under the influence of an electric field. Under normal conditions, current i_1 represents the maximum intensity permissible in the conductor, while this maximum intensity is increased to i_2 under the influence of an electric field.

All the above facts deal with conditions of space in a normal, stationary atmosphere. But the same effect will appear if there is a flow of air along the conductor in question. Suppose that air is moving at a certain velocity v_0. Conductor F, which has previously been brought to a state of incandescence, is then cooled, and leads to a change in conductivity. We can again bring conductor F to a state of incandescence by acting on the rheostat, and then we connect the source of high voltage through contact P. The effect of the influence of the electric field E on the conductivity of conductor F is fully reproduced. FIGURE 3 shows the scheme of this last experiment.

The influence of an electric field on carbon conductors has slightly different aspects: for example, the lead rod of an average hard pencil will change color when it is brought to a state of

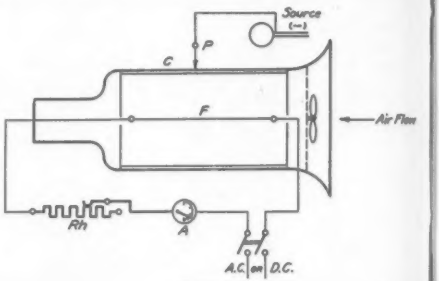


FIGURE 3

incandescence. A clear, yellowish-red color outside of the field will change to a pale blue color under the influence of the field, and one can easily observe that this incandescence, while changing in color, also changes its position by gradually moving from the periphery to the inside part of the conductor. The Corona effect, as well as the space current effects can easily be attained with carbon conductors.

The influence of an electric field is equally significant on electric sparks. If a continuous spark is established under a definite pressure between two pointed electrodes, and is supplied by a direct or an alternating current, it will change its aspect under the influence of an electric field: it seems to twist and to diminish, becoming at the same time more compact.

Conclusion and Theoretical Discussion. What conclusions can be drawn from the experiments briefly described above? First of all, we can conclude that the influence of an electric field,

moving in a radially concentric manner towards the conductor, creates an effect only when a current passes through the conductor, since this effect is not noticeable if the current is of a very low intensity. Therefore, the electric field acts on the electric current and not on the real condition of the resistance or of the conductivity of metals. In other words, this influence must be acting upon the conduction electrons, or, according to the new theories of physics, upon the electronic waves spreading through the conductor. The previously-described effect of an electric field on an electric current in the so-called "cool conductors" (absence of incandescence), the effect resulting in a practical vacuum in negative electric fields, and the effect obtained in a flow of air, all support the theory that in this case there is no sign of the thermionic effects known to us in physics. Consequently, the classical ionization

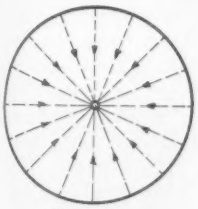


FIGURE 4a

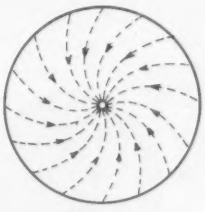


FIGURE 4b

of the medium separating the walls of the cylinder from the conductor, and the establishment of the conventional current (the flow of positive and negative ions towards opposite poles) appear doubtful and rather impossible. This is even more so for the reason that there is no closed electric circuit along which an electric current could flow between system P and system F.

We must conclude, therefore, that there are other theoretical considerations. It seems much more probable to us that electrical charges of only one type flow along the lines of the established electric field E.

For example, in the case of a negative electric field, the electrons move radially from the inner walls of the cylinder towards the conductor. Experience confirms these considerations, and we can find, and even measure, such electrostatic charges on the tested conductor. If an electric field E is established around a conductor which is not carrying any current, but which is simply suspended in space, or grounded, the lines of force of the electric field will definitely be symmetrical, and will be directed along the radii, as is shown in FIGURE 4a. The result will be quite different, however, if an electric current i flows through conductor F. We know that every electric current is accompanied by a whirling magnetic field along the outside of the conductor. The electric lines of force are of the same nature as the magnetic lines. They act upon one another, and can combine by forming electromagnetic lines of force (we are acquainted in physics with such formations, for example, Maxwell's electromagnetic fields). We can conclude, therefore, that an electric field acting on an electric current finds a degree of resistance on the part of the magnetic field. The magnetic field reacts on the electric field, and it is quite logical that there results the phenomenon of the interaction of the electric and magnetic fields. In this case, the direction of the electromagnetic lines of force is not along the radius, but along spiral-like curves in space, as shown in FIGURE 4b. These lines carry with them free electrons which are probably mixed with negative ions when the action takes place in a normal atmosphere. In a vacuum, however, these lines carry mainly electrons. In order to tear away the electrons from the metal (in our case from the cylindrical body) we need a fairly intensive electric field. This can explain the straight sections of the curves, parallel to the axis of the abscissa, shown on FIGURE 2. In other words, it can explain the presence of the critical field E_0. Apparently, if field $E < E_0$, the force of ejection of electrons from the metal is insufficient, and, therefore, there is no sign of the influence on the electric current in the conductor. This condition can be compared with the critical value of the electric field when the so-called "electrostatic pressure" causes the discharge of the charged body. In this last condition, the critical field is evaluated at 30 kV per cm, while in our case the critical field, at which the effect will begin, is equal to approximately 1 kV per cm.

The presence of an interaction between the electric and the magnetic fields is confirmed in the experiment by the formation of electrical turbulences. If aerosols, colored gases, or smoke are introduced into the apparatus depicted in FIGURE 5, we can readily observe the turbulent movements. These movements have the same direction as the whirling magnetic field which accompanies the electric current. If we change the direction of the direct current in conductor F, we shall automatically reverse the direction of the magnetic

field. The electrical turbulences will also change in direction. FIGURE 6 shows two photographs of electrical turbulences in smoke: photograph *a* corresponds to the case where the current flows from the observer towards the drawing, while picture *b* shows the reverse—the flow of current from the drawing to the observer.

It is interesting to note that by varying simultaneously the electric and the magnetic field, at a certain moment a point is reached when the interaction between the electric and the magnetic fields sets in motion the conductor situated along the axis. The conductor rotates in a whirling movement, forming a regular pattern at various frequencies $f_1, f_2, f_3 \cdots f_n$. When the conductor is incandescent, the whirling movement acquires a bright, pictorial form which can easily be photographed and which assumes the appearance of electromagnetic lenses. The shape of the whirling movement of the conductor corresponds to the equation of the projection along the x axis:

$$\frac{d^2r}{dt^2} = -\frac{1}{2}\frac{e}{m} r \left[\frac{e}{m} H_x^2 + E_x''\right];$$

$$\frac{d\theta}{dt} = -\frac{1}{2}\frac{e}{m} H_z \text{ and}$$

$$\frac{d^2x}{dt^2} = -\frac{e}{m} E_x'.$$

Frequency f is increased by a greater interaction of the fields, but the motion of the conductor stops at one point. Apparently the magnetic field becomes too great by comparison with the concentric electric field, and the flow of electrons from the closed cylindrical system towards the conductor ceases at that moment.

The above described pattern may also have the shape of a double lens, with an interception in the central part. Very low frequencies can be achieved by a gradual regulating of the fields, while the movement of the conductor is easily observable to the naked eye.

The effect which takes place within conductor F itself, when such significant changes in the condition of conductivity occur in it, remains to be explained. The following must be considered: we know that in conductors, the conduction electrons which form the electric current either spread themselves relatively equally over the whole cross-section of the conductor (direct current), or distribute themselves mostly along the outside of the cross-section of the conductor (alternating current); with the rise in frequency and voltage, the conduction electrons can occupy the supreme peripheral position (Corona effect). We know from the study of electrostatics that any electric field acts on the electrical charges in a metal by displacing in it the electrons in the direction of the electric field. In the case of a negative electric field, the electrons will be repelled and will adopt a position as distant as possible with respect to the field. The part of the metal which is most removed with respect to the field will be charged negatively, while the part closest to the field will have a positive charge. This phenomenon is known under the name of electrostatic induction.

On the basis of these considerations, we can suppose that if the conduction electrons are

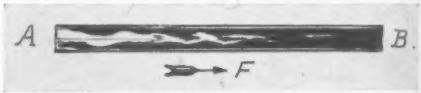
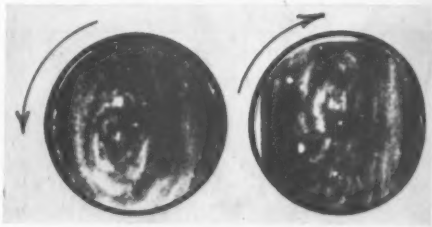


FIGURE 5



a *b*

FIGURE 6

subject to such an electrostatic repelling effect, they will undoubtedly displace themselves within the conductor in the direction of the action of the electric field. All depends only on the intensity of this outer field since, if this intensity is insignificant by comparison with the electromotive force which creates the current in the conductor, then the repelling of the electrons will be insignificant and unnoticeable. If the force of the electric field acts in an absolutely symmetrical manner on the electric current, as in our case, in a concentric manner and equally in every point of the conductor, then the displacement of the conduction electrons must also take place symmetrically, from the outer part of the conductor towards its interior. In other words, if the density of current within the conductor was the same, d_0, before the action of the electric field, then under the influence of the field the density in the interior

of the conductor will be $d_1 > d_0$, while in its outer part it will be $d_2 < d_0$. In the case of an alternating current of high voltage, if the outside density d_2 of the electric current is considerably larger than the inside density, $d_2 > d_1$ before the action of the electric field, the influence of the electric field will cause a displacement, and the density of the interior part d_1 will become greater than the outside density d_2; we shall then have $d_1 > d_2$. We should like to point out, however, that such a subdivision into two densities is only figurative, intended for a better understanding of our discussion. In reality, under the influence of the electric field the density in the whole cross-section of the conductor will change progressively in the direction of the axis of the conductor.

There is a legal basis to our hypothesis. It does not contradict the existing facts, and is confirmed by other analogous experiments the apparent change in color in carbon conductors, and also, the change in electric sparks, p. 168). An interesting experiment can be made with a tiny electronic mass. If a metal tube of the same charge, for example negative, is inserted into the cathode oscillograph instead of two plates denoting two different electrodes of an electric field, we shall create the conditions of a symmetrical electrostatic repelling action. In reality, if prior to the connection of the electric field, the electronic mass left a spot of diameter d_1, on a fluorescent screen, after the connection this spot would progressively diminish in size with the rise in the intensity of the electric field. The changes in the diameter of this spot under the influence of the electric field are very rapid, reaching 10^{-7} of a second.

Before concluding our discussion of the chief considerations of the influence of an electric field on the electric current, we should like to mention one more very important situation. The phenomenon of interaction between the electric and the electromagnetic fields created by this effect, and leading to the formation of electrical turbulences has a very interesting function: the decomposition of gases, smoke and steam. The splitting of the molecules of gas and smoke is evident. The action is immediate and, in the case of colored gases or smoke, one can clearly observe the formation of turbulences. The experiments show that the molecules of a gas, for example, oxygen, are ejected from the apparatus, while all the solid particles remain in the apparatus, and are deposited on the walls of the cylindrical body. Naturally, in the experiment with the decomposition of smoke it is necessary to enclose the apparatus in a closed, well-isolated container. FIGURE 5 shows the decomposition of smoke along the conductor. From side A we supply a constant flow of smoke which is gradually destroyed by a chemical process of decomposition, while we notice with the help of a flame a flow of oxygen from side B (the oxygen feeds the flame).

The explanation of this last phenomenon must be found in electronic effects. Apparently, the free electrons which pierce the molecules of the gases, partly join them and, in so doing, destroy the interior, electrostatic forces which hold together the molecules. A molecule which loses these interior holding forces, decomposes into its original elements. This action takes place without any use of thermic energy. The splitting of the molecules is done by the electrons which, in our case, are specially directed by the interaction of the electric and the magnetic fields.

At the present time, we are still working on this question, and we hope that in the near future we shall be able to present a more detailed report.

SECTION OF PSYCHOLOGY

EXPERIMENTAL SEMANTICS*

By GREGORY RAZRAN†

The title, "Experimental Semantics," is perhaps a bit ambitious and too inclusive. What I am really going to talk about is "semantic conditioning," an expression I first used in an article in *Science* in 1939.[10] I was then at the end of a five-year period of rather extensive experimentation in conditioning and in conditioning to verbal stimuli, and "semantic" seemed to be the term best fitting an effective but unnamed, and otherwise little accountable, CR variable. I was not, of course, the first to form conditioned responses to verbal stimuli. Shastin of Krasnogorsky's laboratory (1927; salivation)[4], Kapustnik of Ivanov-Smolensky's laboratory (1930; withdrawal from electric shock, and instrumental food-getting)[2] in the Soviet Union, and Hudgins (1933,

* This paper was presented at the meeting of the Section on January 21, 1952.

† Department of Psychology, Queens College, Flushing, New York.

iridic contraction and dilation)[1] in this country, preceded me. However, while these three studies aroused considerable systematic interest in their time, it remains true that, first, verbal conditioning has been to date a neglected area of research amidst a rampant field of speculation and deduction; and second, the chief specificity of verbal conditioning (*i.e.*, its semantics) has been hardly touched at all as an experimental problem. The number of reported laboratory conditionings to words and sentences is singularly small (so far as I know, even our American classic, the most conditioned reflex, the eye-wink, has not been experimentally conditioned to a verbal stimulus). And those that have appeared, particularly in Russian studies, have treated words and sentences as merely another set of stimuli to be conditioned, without any thought of analysing what it is in the words or sentences that is being conditioned, and without even an attempt at a quantitative comparison between verbal and sensory conditioning. Yet, not only is Russian psychological literature replete with numerous lengthy discussions of what words or sentences specifically do, or are supposed to do, as conditioned (or associated) stimuli (or responses) in psychosomatics and psychotherapy, hypnosis and suggestion, mass and individual education and re-education, and what not; but we ourselves, in recent years, have mobilized a great deal of effort in attempts to utilize and extrapolate special conditioning findings (as found or putatively found in non-verbal rats and experimentally de-verbalized college students) not only to general—largely verbal—human behavior, but also to its social and abnormal manifestations whose very core is verbal and semantic. Let me begin with my own studies, their methodology, results, and postulated interpretations.

In all my conditioning studies I have used food and eating as the unconditioned or conditioning stimulus or agent. I think they are good conditioning agents to use, particularly if we disregard some difficult mensural problems. Eating is obviously a normal, natural, usually meaningful, typically pleasurable, both highly conscious and deeply unconscious, total organismic activity. Yet it has, of course, a number of reflexive and segmental motor and glandular outlets and manifestations. When repeatedly used, as conditioning experimentation demands, eating does not induce in human subjects the impression of a laboratory artifact, in the manner of repeated abient stimuli such as electric shocks, sudden taps, air-puffs or sounds. And unlike abient stimuli, it does not teem with so much motivational ambivalence and signallings (*i.e.*, something to do, something to avoid) as eating is really more an end than a means. Furthermore, since the success of human conditioning depends a great deal upon the control of the subjects' attitudes (*viz.* misinforming the subjects about the true nature of the experiment), we have here another advantage. Consider, for instance, a college freshman consuming tea-sandwiches while silently studying on a screen paired associates of a Russian-English vocabulary. The freshman is instructed to pay close attention to his learning task and yet to attempt to enjoy his food maximally, and is told that the purpose of the experiment is to investigate the relation between learning ability and digestion. The freshman's mastery of the Russian words is occasionally tested, samples of his saliva are frequently and regularly taken and tested—all of which create and continue to create a naturalness that only a rare specimen of a subject would question, and one that would indeed be difficult to duplicate with abient experimentation. Thus, I am tempted to repeat that, except for mensuration, I can think of no better conditioning agent for human subjects than food, unless it be sex, but this is even more difficult to control and measure.

I mentioned mensuration difficulties in eating experiments, and they are of no mean magnitude. I have used, as I said, the secretion of saliva as an index of eating conditioning, and at the beginning of my experimentation I tried saliometers, but they were too disturbing to the subjects and on the whole not too accurate. Later, I substituted the weighing of dental cotton wads which yielded fine measurements, but this, too, is far from satisfactory. For one thing, the method is painfully slow: an experimenter, an assistant and the subject have to work carefully for a whole hour to obtain 20 or less single readings of a single subject. For another thing, the subjects have to be very conscientious and imbued with a faith that the experimenter is somehow able to detect needless and heedless tongue and cheek movements. I have always used naïve subjects, always paid them, and sometimes fired some just to keep up the pretense of my omniscience. Frankly, if someone invented some good and ready technique for quick and exact measurements of some index of eating conditioning, the invention, I think, might well be worth several theorems to the future of learning theory and psychology. Again, I should like to note that

by no means do I want to suggest that experiments in abient conditioning are of little significance, but merely that adient studies are likely to yield more consistent results, and that abient experimenters must take particular care in the use of subjects and in the control of their attitudes.

GET HERE; while in the second experiment, B,[8] the comparisons were between the nonsense syllables without special instructions and the same nonsense syllables to which instructions had been added that they meant saliva in Benga, an African language. Neither method was too

TABLE 1

PROCEDURES USED IN SEMANTIC CONDITIONING (SUMMARY)

Experiment	*Conditioned stimuli*	*No. Ss.*	*Testing method*
A	ZAG DIH, WEX BUH vs. 257 839; GET HERE	12	Conditioning and extinction
B	ZAG DIH, WEX BUH vs. ZAG DIH, WEX BUH plus instructions that they mean saliva in Benga, an African language	8	Conditioning and extinction
C	Russian words *vs.* English words while learning a Russian-English vocabulary: Nashla—found, yemu—him, belokuraya—light-haired, pero—pen, dal—gave, myach—ball, ona—she, khochet—wants, kupit—buy, serry—gray, novy—new, devochka—girl, ya—I, zolotoye—golden, koshelok—purse	15	Conditioning, extinction
D	Style, urn, freeze, surf	3	Transfer words: fashion, vase, chill, wave
E	Dog, dark, flower, day, mineral, goat, lock, bake	8	Transfer words: animal, terrier, bark, cat; afraid, light, room; pansy, petal; night, week; copper; animal, horns, sheep; key; sun
F	Dog, copper, flower, attic, day	9	Transfer words: animal, cat, terrier; metal, iron; pansy, petal; house, cellar; night, week, hour
AA	1. Poverty is degrading. 2. Roosevelt will be elected. 3. Socialism is desirable.	3	Transfer to 7 variations of each sentence
BB	1. Ona khochet kupit serry koshelok—She wants to buy a gray purse. 2. Ya dal yemu novy myach—I gave him a new ball. 3. Belokuraya devochka nashla zolotoye pero—The fair-haired girl found a golden pen.	8	Fractionation and colligation
CC	Various portions of preceding 3 sentences	8	Conditioned inhibition

The use of psychology students in conditioning experiments should be especially discouraged.

Now, the specific procedures for detecting and isolating semantic factors in conditioning, as given in TABLE 1, may well be discussed, for lack of space, together with the results and interpretations of each experiment, as presented in TABLE 2 and in FIGURES 1 and 2. In my first experiment, A,[6] I merely compared the conditionings and extinctions of two pairs of nonsense syllables, with two 3-place numbers, and with the words

satisfactory. The first did not rule out phonetographic inequality of nonsense syllables and words, and the second permitted no quantification of meaning, and required equated groups. Furthermore, in these first two experiments I have not yet controlled the subjects' attitudes, so that little conclusiveness should be attached to their results. Indeed, the finding in Experiment A, that nonsense syllables are more conditionable than words, was not borne out (more correctly, it was reversed) by a later study in which attitudes

were controlled. Then, the somewhat obvious finding in Experiment B, that imparting the meaning of "saliva" to nonsense syllables greatly enhanced salivary conditionability, is most probably also an attitudinal matter: the subjects' understanding their tasks to be to secrete saliva upon the presentation of the particular nonsense syllables.

However, I reached an adequate CR semantic methodology in my third experiment, C.[15] The subjects here were conditioned to paired associates English words. The two main findings of the experiment were: (1) that meaningful English words were more conditionable than meaningless Russian words; and (2) that the more meaning the Russian words acquired the more resistant they became to extinction. The second finding is much more significant, both because it was based on many more observations and because in salivation, as well as in some other CR experimentation, extinction is a ready and serviceable index not only of itself but also of strength of

TABLE 2
RESULTS OF SEMANTIC CONDITIONING (SUMMARY)

Experiment	*Chief Findings*
A	1. Nonsense syllables more regularly and more readily conditioned than words; differences in extinction not clear-cut.
B	1. Attachment of meaning of "saliva" to nonsense syllables improved greatly conditioning.
C	1. Meaningful English words more conditionable than meaningless Russian words. 2. The more meaning the Russian words acquired the more resistant they became to extinction; but new meaningful Russian words were somewhat more resistant to extinction than old meaningful English words.
D, E, F	Per cent of transfer
	Synonyms 59 — Part-whole 36 Supraordinates 43 — Predicatives 35 Contrast 42 — Subordinates 24 Coordinates 39 — —— Whole-part 38 — Homophones 37
BB	Relative CR weights of syntactical units
	Sentence: — Weights: 1. Ona khochet kupit serry koshelok—She wants to buy a gray purse. — Subject—14%, verb—20%, infinitive complement—26%, direct object—28%, adjective qualifying direct object—12% 2. Belokuraya devochka nashla zolotoye pero—The fair-haired girl found a golden pen. — Adjective qualifying subject—13%, subject—18%, verb—30%, adjective qualifying direct object—13%, direct object—26% 3. Ya dal yemu novy myach—I gave him a new ball. — Subject—9%, verb—35%, indirect object—18%, adjective qualifying direct object—11%, direct object—27%

of a Russian-English vocabulary while eating and being told that the purpose of the experiment was to study the relation between learning ability and digestion. Motivation and attention were excellent, attitudes were controlled, and the gradual acquisition of meaning (semantization) by the Russian words made meaning and conditioning true experimental independent-dependent variables; as the conditionability and extinguishability of the Russian words, at different stages of semantization, could be compared with each other, with those of English words, and with those of Russian words that had not been paired with conditioning. The finding is strikingly similar to the direct relationship between resistance to extinction and intra-modal stimulus complexity which I obtained in configural conditioning.[7, 8] It is even more like the relationship between resistance to extinction and conditioning involving more than one modality, found by J. Miller with the eye-lid response[6] and by me with salivation.[7, 8, 16] My interpretation is that the acquisition of meaning by words adds to the words a new dimension, a dimension similar to a sense modality (adding hearing to seeing) or to a separable dimension within a modality (adding color to form); and,

in neural terms, that it occasions the emergence of new brain patterns—and loci.

The methodology in the fourth experiment, D,[10] succeeded in unveiling another phase of semantic conditioning. Here, the subjects were originally conditioned, at different times, to words STYLE, URN, FREEZE, and SURF, and then tested respectively with synonymic transfer words FASHION, VASE, CHILL, and WAVE (as well as with homophonic transfer words STILE, EARN, FRIEZE, and SERF). When the synonymic transfer words showed a considerable amount of conditioning (more than homophonic words)* it was argued that, since the synonymic transfer words and the originally conditioned results (I reject the hypothesis of mediate generalization as unnecessary, strained, and less testable).[17, 18] Again, in Experiments E and F,[11, 13, 14] I studied CR transfer to semantically related words in terms of the traditional associative categories: supraordinates, contrasts, coordinates, predicatives, and the like. The results showed such transfer to occur, but failed to differentiate among the separate categories, except to place subordinates at the bottom of semantic relatedness. The variables here are too complex and the results too incomplete and tentative to warrant any summary interpretation.

A more complex and special extension of the transfer method was used in Experiment AA.[12]

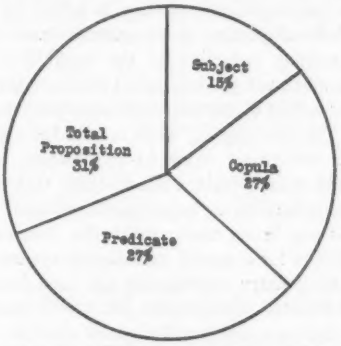


FIGURE 1. Experiment AA. CR semantic analysis of propositions "Poverty is degrading," "Roosevelt will be elected" and "Socialism is desirable." Relative CR weights of propositions (independent of particular terms), and of particular terms.

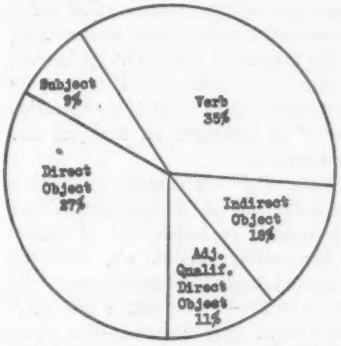


FIGURE 2. Experiment BB. CR semantic analysis of "I gave him a new ball" and "Ya dal yemu novy myach." Relative CR weights of individual syntactical units.

words had little in common phonetographically, the residue conditioning to the transfer words was purely semantic, due to semantic factors. My interpretation here, too, would be in terms of a separate neuropsychological semantic dimension; namely, that conditioning to words involves a modification of two separable brain patterns: A, corresponding to the phonetographic pattern of the words, and A^1, corresponding to the semantic equivalent of the words. When the phonetographic pattern is changed, the conditioned semantic equivalent is still there to take over and produce

Here I was interested, not in the semantics of individual words, but in the semantics of total sentences, judgments, beliefs, and propositions. My subjects were thus first conditioned to three simple sentence-propositions "Poverty is Degrading," "Roosevelt will be Elected," and "Socialism is Desirable," and then tested when the subjects of the propositions or their predicates or the copula words, or two of them, or all three of them, were reversed: e.g., "Poverty" to "Wealth," "Elected" to "Defeated," "Is" to "Is Not," and the like. The reversals obviously confirmed the original propositions in some cases but negated them in others, thus making it possible to ascertain not only the relative CR weights of each term of each proposition, but also the relative weights of the propositions themselves, independent of particular terms ("Wealth

* Greater CR transfer to synonyms than to homophones was also found by Riess using the GSR and college students,[19] while in another experiment,[20] using subjects ranging in age from 7 to 20 years, Riess found a positive correlation between relative synonymic transfer and age. In my own studies, relative synonymic transfer typically increased with practice but often decreased with over-practice, which may mean, if we adhere to the parallel of age and practice, that synonymic transfer would decrease and homophonic increase, after some age period (de-semantization).

is Uplifting" being, for instance, considered here equivalent to "Poverty is Degrading"). The results (means for the variations in all three sentences, as inter-sentential differences were surprisingly small) are given in FIGURE 1, and, as seen, show that propositions were preponderant, predicates and copulas followed, and subjects trailed behind. The finding is similar to the one I, and others, obtained in configural conditioning in which subjects conditioned to musical intervals had shown more CR transfer to the same musical intervals in different keys and octaves (thus containing different constituent tones) than to musical intervals having some common tones with the original conditioned intervals but being, nevertheless, different intervals.[9] Of course, in music we have the unifying mathematical factor of common tone ratios, while it must be something else that holds together a proposition, judgment, or belief differently expressed. Perhaps, the similarity is no more than a result of the operation in each case of an emergent, an emergent and separate brain pattern.

In Experiment BB,[15] my concern was with a semantic analysis, not of sentence-propositions expressing judgments or beliefs, but of typical five-word (disregarding English *a*'s, *to*'s, and *the*'s) Russian and English event-sentences: "Ya dal yemu novy myach—I gave him a new ball," "Ona khochet kupit serry koshelok—She wants to buy a gray purse," and "Belokuraya devochka nashla zolotoye pero—The fair-haired girl found a golden pen." More specifically, I wanted to ascertain the relative weights of common syntactical units (subjects, verbs, direct objects, indirect objects, infinitive complements, qualifiers) in sentences, as reflected in the net effects of sentence-membership upon the conditionings of constituent words. The systematic problem here was the mutual interaction of parts in a pattern rather than, as in Experiment AA, the emergence of independent patterns from parts; and for this I utilized two other characteristics of conditioning: fractionation and colligation. Four of my eight subjects were conditioned to the total sentences and tested for residue conditioning of constituent words (fractionation), while the remaining four subjects were conditioned to the constituent words and tested when the words were made into sentences (colligation), the combined results affording a fair measure of the net effects of sentence-membership upon constituent units. The results, given in FIGURE 2, indicate: (1) preponderant effects of verbs and direct objects; (2) considerable weights of infinitive complements; and (3) small weights of subjects, greater when they are nouns than when they are pronouns, and of indirect objects, and qualifying adjectives. The exact percentages of the weights are no doubt tentative since allowance should be made particularly for specific effects of specific words; yet the relative rankings of the syntactical units may well be considered established, within the limits of the present technique. As to Experiment CC, only its method, conditioned inhibition, will be described, since its results have not yet been analyzed. Briefly, the method, as its name implies, involves the conditioning of subjects to a portion of a sentence, then testing them when a nonconditioned portion is added to the conditioned portion of the sentence, and taking the resulting reduction of the conditioning to the conditioned portion, as an index of the strength or weight of the non-conditioned portion.

In summing up, while my studies may well be of systematic value to Psychology, Semantics, and related fields, I like to think that their main contributions are largely methodological. Pavlov, as you know, used conditioning data as building blocks for a special neurological system, while in this country conditioning has been fashioned by influential psychologists into a wide basis for, we might say, psychophilosophical systems. I hope I do not sound too modest, if I say that I belong to neither group. To a large extent, my interest in conditioning is similar to the original interest of Watson, namely, as a method (I differ with Watson in most other respects). We have in Psychology a number of areas which need to be objectified and quantified, and this can be done only indirectly through conditioning. A histologist, unable to observe damaged tissue directly, may learn about it through differential staining, and conditioning is to me a kind of staining, differential conditioning, differential staining. For this we must have better stains, better instruments, better methods, and better designs, and not much of it has been forthcoming in recent years. Instead, we have elaborate theoretical systems, and, forgiving my metaphors, very narrow bridges of old rickety facts, suspended over very wide and gaping gorges of ignorance. This does not seem to me the road to progress for psychology. We are an empirical science, and we will not be saved by clever schemes, even though stupid experiments are not exactly an

antidote for it. We need, of course, some theory and a program of selective experimentation. But this is not the same as the many prophet-like predictions, pontifications, and partisanships that have been reigning in our field for some time. It is time to change and return to normality: observation and experimentation.

Bibliography

1. Hudgins, C. V. 1933. Conditioning and voluntary control of the pupillary light reflex. J. Gener. Psychol. **8:** 3.
2. Ivanov-Smolensky, A. G. (Ed.) 1930. Basic Mechanisms of Conditioned Reflex Activity in Children. Moscow-Leningrad. P. 11–22.
3. Ivanov-Smolensky, A. G. (Ed.) 1934. Studying the Highest Forms of the Neurodynamics of Children. Moscow. P. 273–450.
4. Krasnogorsky, N. I. 1931. Bedingte und unbedingte reflexe in Kindesalter und ihre Bedentung fur die Klinik. Ergeb. inner. Med. Kinderlik. **39:** 613.
5. Miller, J. 1939. The rate of conditioning of human subjects to single and multiple conditioned stimuli. J. Gener. Psychol. **20:** 399.
6. Razran, G. 1935. Conditioned responses: an experimental study and a theoretical analysis. Arch. of Psychol. **28** (191): 124.
7. Razran, G. 1939. IV. Gestalt organization and configural conditioning. J. of Psychol. **7:** 3.
8. Razran, G. 1939. VI. Comparative extinction and forgetting of single-stimuli and of pattern conditioning. J. Exper. Psychol. **24:** 432.
9. Razran, G. 1938. VII. Ratios and elements in the salivary conditioning to various musical intervals. Psychol. Rec. **2:** 370.
10. Razran, G. 1939. A quantitative study of meaning by a conditioned salivary technique (semantic conditioning). Science. **90:** 89.
11. Razran, G. 1949. Semantic and phonetographic generalizations of salivary conditioning to verbal stimuli. J. Exp. Psychol. **39:** 342.
12. Razran, G. 1949. Sentential and propositional generalizations of salivary conditioning to verbal stimuli. Science. **109:** 447.
13. Razran, G. 1949. Some psychological factors in the generalization of salivary conditioning to verbal stimuli. Amer. J. Psychol. **62:** 247.
14. Razran, G. 1949. Stimulus generalization of conditioned responses. Psychol. Bull. **46:** 337.
15. Razran, G. 1949. The dynamics of conditioning to verbal stimuli. Program, 116th Meeting, A.A.A.S. 208. (Newsweek. Jan. 2, 1950. **35:** 46.)
16. Razran, G. 1950. The extinction of conditioning to verbal stimuli. Amer. Psychologist. **5:** 486.
17. Razran, G. 1950. Multiple conditioning, surrogate conditioning, and stimulus generalization. Amer. Psychologist. **5:** 265.
18. Razran, G. 1951. Reply to Grice's "Comments on Razran's Discussion of Stimulus Generalization." Psychol. Bull. **48:** 153.
19. Riess, B. F. 1940. Semantic conditioning involving the G.S.R. J. Exp. Psychol. **26:** 238.
20. Riess, B. F. 1946. Genetic changes in semantic conditioning. J. Exp. Psychol. **36:** 143.

SECTION OF OCEANOGRAPHY AND METEOROLOGY

PROBLEMS ASSOCIATED WITH EXTENDING THE TIME RANGE OF WEATHER PREDICTION*

By JEROME NAMIAS†

A fact which hardly needs clarification to the newspaper-reading public is that weather prediction is not an exact science. Because of its inexact character many people, meteorologists included, speak of the "art" of weather forecasting. Yet in spite of imperfections, weather forecasts for a day ahead are of great economic value throughout the world. The level of skill of these forecasts, moreover, compares quite favorably with predictions made in many other fields of human endeavor.

Because weather phenomena are often persistent and repetitive, cumulative effects of major concern to the economy are observed everywhere. Such catastrophes as drought and flood are examples of these persistent or recurrent weather regimes. The non-random nature of such phenomena makes their prediction especially challenging.

The problem of extending the time range of weather prediction might be simplified by finding some method of submerging the detail of weather which is observed on a day-to-day basis, and dealing at first only with the long period "regimes" or spells of weather. It has become clear to most meteorologists that it is futile to attempt to forecast the weather for a sequence of days up to a week or more by mere extrapolation of the day-to-day weather maps.

One of the first serious attempts to explore the possibilities of long-range forecasting was made by the French meteorologist Teisserenc de Bort who, by the simple process of constructing mean or average charts for a month from daily weather maps, discovered the great centers of action of the atmosphere's general circulation. Moreover, he succeeded in generally relating the weather regime of a given month to the displacements and intensities of the centers of action relative to

* This paper, illustrated with lantern slides, was presented at a meeting of the Section on January 22, 1952.

† Chief, Extended Forecast Section, U. S. Weather Bureau.

their normal (long-period average) positions and intensities. From the time of Teisserenc de Bort (1855–1913) until the present, a large amount of work has been done in an attempt to find the key to the astonishingly large weekly, monthly, seasonal, annual, and even decennial variations in the character and displacements of the centers of action. Similarly, considerable research has been done relating the weather to these centers.

The latter problem is much simpler than the former. During the past five years, a reasonably successful objective method of relating temperature abnormalities to the centers of action has been developed.[1] Possibly, because of the relative ease of solving this problem, some workers have underestimated the complexity of the primary task of predicting the state of the general circulation which, through the centers of action, governs the weather regime. For example, the "weather-type" approach[2] to extended forecasting offers a reasonable and informative classification of regional weather regimes based on the configurations of one or more centers of action, but it provides no solution as to what "type" (*i.e.*, character of the centers of action) will arise, let alone how, or when, it will arise.

Until the past decade, attempted methods of predicting the evolution of the centers of action were almost entirely statistical in character. The method of linear correlation found a secure niche in the research institutions of meteorology, and correlation zealots were to be found everywhere, numerically relating every meteorological element to every other element elsewhere and for different periods of time. The correlation approach still occupies a prominent place in long-range forecasting research, but today it is largely the servant, not the master, of the researcher. Instead of wading through thousands of correlation coefficients in the hope of finding large and "significant" values, the modern researcher has a theoretical framework to guide his activities.

This framework provides, for the first time, a physical explanation of the interconnections between the centers of action. It is the well-known theory of waves in the westerlies, due primarily to Rossby[3] and Bjerknes.[4] Despite the fact that these scientists, Rossby especially, pointed out the interrelationship between the centers of action, neither one claimed that the proposed theory had any connection with circulations involving time periods as long as a month. Indeed, considering the fact that Rossby's derivation has as its nucleus the conservation of the total absolute vorticity about the vertical, it is not surprising that he, as well as others, was shocked to hear of its application to such hybrids as 30-day mean charts.

Nevertheless, over the past ten years, empirical work with 30-day mean charts unquestionably exhibits the general interrelationships between the centers of action indicated by the vorticity concept.[5] The spacings between the great ridges and troughs in the mid-tropospheric westerlies, for example, are related to wind speed, and thereby the position and intensity of one trough or ridge are related to its upstream and downstream neighbors. Because of these relationships, it is possible to find simultaneous correlations between the departures from normal of mean monthly height of the 700 mb. surface at points separated by over 4000 miles. A number of indicative statistics of long waves on monthly mean charts are to be discussed in a forthcoming report by Klein.* Surprisingly enough, these involve not only contemporaneous correlations but also time-lags of the order of a month, as suggested earlier by the present author.[5]

The formidable question arises as to why a model developed for use on daily circulation patterns seems to have some validity when applied to averages for long time intervals. In part, or perhaps totally, this result may be due to the serial correlation which infiltrates all continuous meteorological data. That is to say, a regional circulation which once becomes established will persist for a time and later recur in essentially the same place and form. Its modifying influence on neighboring circulations through the flux of vorticity will be essentially the same during each persistent and recurrent stage. Consequently, a preferential wave pattern will predominate and give rise to internally harmonious patterns of the general circulation.

Nevertheless, this persistence and recurrence cannot account for the lag relationships indicated in the empirical-statistical work cited. Indeed, no satisfactory explanation has been offered for the large abnormalities of the entire complex of centers of action which make up the general circulation. On the other hand, we have learned that if a large anomalous perturbation is produced in one part of the westerlies, other anomalous features, some of them predictable, will appear in

* Paper presented before the New York Meetings of the American Meteorological Society, January 28–31, 1952, entitled, "Some Properties of Long Waves on Monthly Mean Charts".

other, even remote, portions of the hemisphere. What produces the primary controlling perturbations, of which there are probably several coexistent, constitutes the central problem of long-range weather prediction.

Experience gained over the past ten years in connection with the U. S. Weather Bureau forecasts (originally experimental and now operational) suggests that the primary factors operating to bring about the large-scale, long-period weather regimes involve the ever-changing amount of radiation received from the sun as it goes through its annual cycle, and the initial state of the large-scale atmospheric circulation. This initial state seems to be well defined by charts which are constructed by averaging over a period sufficiently long (*i.e.*, two weeks to a month) to suppress the small-scale, chaotic phenomena.

Such a mechanism for the evolution of different circulations, described in more detail elsewhere,[6] indirectly considers the possibility of variations in ocean current temperatures, snow cover, and other terrestrial "controls", but does not take into account irregular, non-seasonal variations in the radiation, whether total or selective, from the sun. In this respect it is at odds with the theories of numerous contemporaries, especially in the United States, who maintain that irregular non-seasonal solar variations are responsible for abnormal weather.

Since the ultimate test of a theory lies in its ability to predict, this difference of views may well be resolved during the current generation. Or possibly the sponsors of the solar school of thought will blame failure to predict abnormal weather on ignorance of solar variations, thereby substituting the problem of forecasting the sun's behavior for that of weather prediction. The predictive skill already attained by methods ignoring non-seasonal, extraterrestrial influences cannot be easily dismissed nor accounted for in terms of these influences.

Thus, there is ample room for research on the anomalous states of the general circulation as reflected by composite or mean maps. To the author it seems that this problem is being ignored by the current generation of theoreticians. It is perhaps too complex for present-day mathematics and physics.

References

1. Martin, D. E. & H. F. Hawkins, Jr. 1950. Forecasting the Weather: The Relationship of Temperature and Precipitation over the United States to the Circulation Aloft. Weatherwise. **3:** 16–19; 40–43; 65–67; 89–92; 113–116; 138–141.
2. California Institute of Technology, Dept. Meteor. 1943. Synoptic Weather Types of North America. Pasadena, Cal.
3. Rossby, C. G. & Collaborators. 1939. Relation between Variations in the Intensity of the Zonal Circulation of the Atmosphere and the Displacements of the Semi-permanent Centers of Action. J. mar. Res. **2:** 38.
4. Bjerknes, J. 1937. Theorie der aussertropischen Zyklonenbildung. Meteor. Z. **54:** 462.
5. Namias, J. 1948. Evolution of Monthly Mean Circulation and Weather Patterns. Trans. Amer. geophys. Un. **29:** 777.
6. Namias, J. 1951. The Great Pacific Anticyclone of Winter 1949–50: a Case Study in the Evolution of Climatic Anomalies. J. Meteor. **8:** 251.

*SECTION OF ANTHROPOLOGY**

THE EXCAVATIONS AT HOTU CAVE†

By CARLETON S. COON‡

In the spring of 1951, working on a grant from the American Philosophical Society, and with the support and encouragement of the authorities of the National Museum of Antiquities of Tehran, an University (of Pennsylvania) Museum expedition conducted excavations at two caves in a limestone cliff near Behshahr, Mazandraan, Iran, four miles from the Caspian shore. Members of the expedition included Dr. and Mrs. C. S. Coon, Mr. and Mrs. Louis B. Dupree, Regional Antiquities Chief Habibullah Samadie, and Mr. Sohail Azari.

First, we completed our dig at Belt Cave, begun in 1949, confirming the presence of two Mesolithic levels underlying a pre-ceramic Neolithic with domestic animals, which, in turn, underlay a true Neolithic with agriculture and pottery. Then, we excavated Hotu, a cave sealed since about 700 B.C. In it we went down 14 meters to a point where the walls were sloping in, and where the

* A paper by Albert M. Kligman, entitled "Modern Aspects of Mushroom Culture," was presented at a meeting of the Section of Mycology, January 25, 1952. The abstract of this paper had not been received prior to the publication of this issue of TRANSACTIONS.

† This paper, illustrated with lantern slides, was presented at the meeting of the Section of Anthropology on January 28, 1952.

‡ Department of Anthropology, University of Pennsylvania, Philadelphia, Pennsylvania.

underlying deposit consisted of a homogenous mass of nearly fluid kaolin. The deposits are divided into three principal cultural complexes: Iron Age, Neolithic, and putatively Pleistocene. The Iron Age level shows a sequence of ceramic and metal forms so far unique, little related to the Iranian plateau sites, and possibly resembling the material from the Caucasus, and the Scytho-Sarmatian animal style. Slag shows that iron was smelted in this ore-rich and charcoal-rich region. The Neolithic specimens start with the software of the Upper Neolithic of Belt Cave, and continue into a transition to painted pottery, similar to Sialk II on the plateau.

The Pleistocene deposit, which has aroused the most interest, consists of a sequence of four gravels and three intervening sands over a succession of three complexes of red gravels and sands, and an underlying black humus. The fauna, in turn, shows an alternation of wet and dry forms, wet represented by ox and pig, dry by gazelle, mole-vole, and thrush. Sheep, a mountain animal, are found in both types; seal are found with the dry fauna only. The black at the bottom is wet, the red complex dry; the upper gravels wet, the sands between them dry. Thus, one may tentatively postulate that the dry periods were times when the Caspian was at its present level. Since the Caspian level depended on the melting of the Fenno-Scandinavian ice sheet, dry equals ice, wet equals melting. In the present fluid state of western European glacial chronology, it is wise to await further developments before interpreting this data.

The flints consist of cores, flakes, flake-blades, and blades. None show the slightest resemblance to the Levalloisio-Mousterian complex, previously discovered to the south and west. Although striking platforms are smooth, most of the implements are crude, partly but not wholly because of the poor quality of the local flint. A minority of implements consists of blades of Aurignacian type, but the tie-in with Europe is not clear. The distance is too great and the intervening gaps too wide. Carbon 14 will, we hope, resolve this question.

In the fourth gravels were found the skeletons of three individuals, a man and two women. The man was robust, belonging to the general Cro-Magnon category. The skeleton of one woman, number 2, is nearly complete. She was tall and slender, with a long, narrow, high-vaulted skull, a large brain, an orthognathous face, a pointed chin, and small modern-type teeth. The second was a short, mesocephalic woman, with arthritis; her face resembled that of number 2. These females, lower in the gravel layer than number 1, seem to resemble a dry-lands adapted form of Upper Palaeolithic man, with no trace of the Neanderthaloid characters shown by the two Mesolithic skeletons from Belt Cave, and by the fourth-millenium population of Tepe Hissar, as well.

As might be expected of pioneer work, this excavation has raised more problems that it has solved.

THE NEW YORK ACADEMY OF SCIENCES

announces

FOUR PRIZE CONTESTS FOR 1952

The New York Academy of Sciences announces the following prize contests for the coming year.

I. THE A. CRESSY MORRISON PRIZE CONTEST

Two prizes of $200 each, to be known as the A. Cressy Morrison Prizes in Natural Science, will be awarded at the Annual Meeting, December, 1952, for the two most acceptable papers in a field of science covered by the Academy or an Affiliated Society.

II. THE A. CRESSY MORRISON ASTROPHYSICAL PRIZE

A prize of $500, in accordance with the bequest of the late A. Cressy Morrison, will be offered this year, and at intervals in subsequent years, to be known as the A. Cressy Morrison Astrophysical Prize. This will be next awarded in December, 1952, for the most acceptable paper in the field of nuclear reactions in astrophysical processes.

III. THE GEORGE FREDERICK KUNZ PRIZE CONTEST

A prize of $200, offered in accordance with the bequest of the late Doctor George Frederick Kunz, to be known as the George Frederick Kunz Prize in Geology and Mineralogy, will be awarded at the Annual Meeting, December, 1952, for the most acceptable paper in the field of Geology and/or Mineralogy.

IV. THE BORIS PREGEL PRIZE IN THE FIELD OF NATURAL RADIOACTIVE SUBSTANCES

Through the generosity of Doctor Boris Pregel, a prize of $200 is offered for the most acceptable paper embodying the results of research in the field of natural

radioactive substances, received in competition during the year 1952, including in this field the precise determination of their physical and chemical properties and constants. The award of this prize will be announced at the Annual Meeting to be held in December, 1952.

CONDITIONS GOVERNING THESE PRIZES

(1) *Eligibility.* Authors and co-authors competing for prizes I and III shall be members in good standing of The New York Academy of Sciences or one of its Affiliated Societies, but non-members may become eligible by joining one of these organizations before the closing date.

Competitors for prize II shall be scientists in good standing, specializing in astrophysical research. There is no restriction as to membership in the Academy or its Affiliated Societies.

Competition for prize IV is open to all scientists engaging in research in the field of natural radioactive substances.

(2) *Date.* Papers are to be submitted on or prior to October 15, 1952, to the Executive Director of The New York Academy of Sciences, 2 East Sixty-Third Street, New York 21, New York.

(3) *Papers.* All papers submitted must embody the results of original research not previously published. The manuscript shall be typewritten, in English, accompanied by all necessary photographs, drawings, diagrams and tables, and shall be ready for publication. Papers must be accompanied by a summary of the data presented and conclusions reached.

(4) *Awards.* The awards shall be made by the Council of The New York Academy of Sciences. The decision of the judges shall be final.

(5) *Publication.* The Academy shall have first option on the publication of all papers submitted, unless especially arranged for beforehand with the authors, but such publication is not binding on the Academy.

(6) Wherever and whenever published, the papers awarded the prizes shall be accompanied by one of the four following statements:

In competition I, "Awarded an A. Cressy Morrison Prize in Natural Science in 1952 by The New York Academy of Sciences;"

In competition II, "Awarded an A. Cressy Morrison Prize in Astrophysics in 1952 by The New York Academy of Sciences;"

In competition III, "Awarded a George Frederick Kunz Prize in Geology and Mineralogy in 1952 by The New York Academy of Sciences;"

In competition IV, "Awarded the Boris Pregel Prize for research on Natural Radioactive Substances in 1952 by The New York Academy of Sciences."

Such a statement, in substance, must also accompany any formal publicity initiated by the author regarding the prize paper. If published elsewhere with the consent of The New York Academy of Sciences six copies of each prize paper must be deposited shortly after publication with the office of The New York Academy of Sciences.

THE NEW YORK ACADEMY OF SCIENCES
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EUNICE THOMAS MINER
Executive Director

CONFERENCES HELD

SECTION OF BIOLOGY

"VIRUS AND RICKETTSIAL CLASSIFICATION AND NOMENCLATURE"

JANUARY 11 AND 12, 1952

The Section of Biology held a Conference on "Virus and Rickettsial Classification and Nomenclature." Sir MacFarlane Burnet, The Walter and Eliza Hall Institute for Medical Research, Melbourne, Australia, was the Conference Chairman in charge of the meeting.

The program consisted of the following papers:

Friday, January 11

Morning Session. Chairman, Sir MacFarlane Burnet.

"Virus Classification and Nomenclature," Sir MacFarlane Burnet, The Walter and Eliza Hall Institute for Medical Research, Melbourne, Australia.

"Concepts of Classification and Nomenclature in Higher Organisms and Microorganisms," Ernst Mayr, American Museum of Natural History, New York, N. Y.

"Viruses that Reproduce in Plants and Insects," L. M. Black, Brooklyn Botanic Garden, Brooklyn, N. Y.

"Problems of Virus Classification and Nomenclature," F. O. Holmes, Rockefeller Institute for Medical Research, New York, N. Y.

"The Nature of Plant Viruses in Relation to Nomenclature," James Johnson, University of Wisconsin, Madison, Wis.

Afternoon Session. Chairman, L. M. Black.

"Decisions of the Fourth International Microbiological Congress in Regard to the Study of Selected Groups of Viruses," C. H. Andrews, National Institute for Medical Research, London, England.

"Advantages of the Linnaean Binomial System for Plant Viruses," P. Limasset, Station Centrale de Pathologie Vegetale, Versailles, France.

"Possibilities of Generic Classification in Rickettsia and Viruses," Geoffrey W. Rake, Squibb Institute for Medical Research, New Brunswick, N. J.

"Criteria for Biological Classification of Bacterial Viruses," Mark H. Adams, New York University College of Medicine, New York, N. Y.

"Discussion of Problem of Imperfect Viruses," A. Bitancourt, Instituto Biologico, Sao Paulo, Brazil.

Saturday, January 12

Morning Session. Chairman, Herald Cox, Lederle Laboratories Division, American Cyanamid Company, Pearl River, N. Y.

"Classification of Rickettsiae—Pathogenic to Vertebrates," (I) C. D. W. Coles, Department of Veterinary Medicine, Department of Agriculture, Onderstepoort, South Africa. (II) C. B. Philip, Rocky Mountain Laboratory, U. S. Public Health Service, Hamilton, Mont.

"Classification of Insect Viruses," (I) G. Bergold, Laboratory of Insect Pathology, Department of Agriculture, Sault Ste. Marie, Ontario, Canada. (II) Edward A. Steinhaus, Laboratory of Insect Pathology, University of California, Berkeley, Calif.

"Criticism of Binomial Nomenclature as Applied to Plant Viruses," F. C. Bawden, Rothamsted Experimental Station, Harpenden, England.

"Psittacosis Virus Group," (I) Karl H. Meyer, The George Williams Hooper Foundation, University of California, San Francisco, Calif. (II) Geoffrey W. Rake Squibb Institute for Medical Research, New Brunswick, N. J.

"Fox Virus Group," E. W. Goodpasture and G.. John Buddingh, Vanderbilt University, Nashville, Tenn., and Louisiana State University, School of Medicine, New Orleans, La.

"Influenza Virus Group," (I) Thomas Francis, Jr., School of Public Health, University of Michigan, Ann Arbor, Mich. (II) Sir MacFarlane Burnet, The Walter and Eliza Hall Institute for Medical Research, Melbourne, Australia.

Afternoon Session. Chairman, John R. Paul, Yale University School of Medicine, New Haven, Conn.

"Arthropod-Borne Animal Virus Group," (I) W. McD. Hammon, School of Hygiene and Public Health, University of Pittsburgh, Pa. (II) Pierre Lepine, Institut Pasteur, Paris, France. (III) A. B. Sabin, The Children's Hospital Research Foundation, University of Cincinnati, Cincinnati, Ohio.

"Coxsacki Virus Group," (I) G. Dalldorf, Division of Laboratories and Research, State of New York Department of Health, Albany, New York. (II) Joseph L. Melnick, Yale University School of Medicine, New Haven, Conn.

"Poliomyelitis Virus Group," (I) A. J. Rhodes, Connaught Medical Research Laboratory, University of Toronto, Toronto, Canada. (II) H. Koprowski, Lederle Laboratories Division, American Cyanamid Company, Pearl River, N. Y.

"Encephalomyocarditis Virus Group," Joel Warren, Army Medical Service Graduate School, Washington, D. C.

"The Virus and Rickettsia Registry, U. S. A.," Joseph E. Smadel, Army Medical Service Graduate School, Washington, D. C.

"The Plant Virus Type Culture Collection," H. H. McKinney, U. S. Department of Agriculture, Beltsville, Md.

"USE OF ANTIBIOTICS IN TROPICAL DISEASES"

JANUARY 17, 18 AND 19, 1952

The Section of Biology held a Conference on "Use of Antibiotics in Tropical Diseases." Doctor H. W. Brown, Columbia University School of Public Health, New York, N. Y., was the Conference Chairman in charge of the meeting.

The program consisted of the following papers:

Thursday, January 17

Morning Session. Chairman, Emanuel B. Schoenbach, State University of New York, College of Medicine and Maimonides Hopsital, Brooklyn, N. Y.

"Introductory Remarks," H. W. Brown, Columbia University School of Public Health, New York, N. Y.

"General Pharmacology of Antibiotics," Harry J. Robinson, Merck and Company, Rahway, N. J.

"Treatment and Prophylaxis of Scrub Typhus and Antibiotics," Charles A. Bailey and Major Herbert L. Ley, Jr., Valley Hospital, Ridgewood, N. J. and Army Medical Service Graduate School, Washington, D. C.

"Treatment of Endemic and Epidemic Typhus with Antibiotics," Vernon Knight, Bellevue Hospital, New York, N. Y., and Francisco Ruis Sanchez, University of Guadalajara, Jalisco, Mexico.

"Treatment of Q Fever with Antibiotics," William H. Clark, Communicable Disease Center, U. S. Public Health Service, Atlanta, Ga.

"Treatment of Rickettsialpox with Antibiotics," Harry M. Rose, Columbia University College of Physicians and Surgeons, New York, N. Y.

"Treatment of Rocky Mountain Spotted Fever with Antibiotics," George T. Harrell, the Bowman Gray School of Medicine, Winston-Salem, N. C.

Afternoon Session. Chairman, Harry M. Rose, Columbia University, New York, N. Y.

"Treatment of Typhoid Fever with Antibiotics," Theodore E. Woodward and R. T. Parker, University of Maryland School of Medicine, Baltimore, Md., and Major C. J. Wisseman, M.C.

"Use of Antibiotics in Tropical Ophthalmology," Alson E. Braley, State University of Iowa, Iowa City, Iowa.

"Treatment of Cholera with Antibiotics," Oscar Felsenfeld, and Dadtraday W. Soman, The Hektoen Institute for Medical Research of the Cook County Hospital, Chicago, Ill., and Haffkine Institute, Bombay, India.

"Treatment of Shigellosis with Antibiotics," F. S. Cheever, Graduate School of Public Health, University of Pittsburgh, Pittsburgh, Penna.

"Problems of Antibiotics in the Treatment of Bacillary Dysentery," Albert V. Hardy, Florida State Board of Health, Jacksonville, Fla.

Friday, January 18

Morning Session. Chairman, Howard B. Shookhoff, Bureau of Laboratories, New York City Department of Health, New York, N. Y.

"Use of Antibiotics in the Treatment of Malaria," G. Robert Coatney and Joseph Greenberg, Laboratory of Tropical Diseases, National Microbiological Institute, Bethesda, Md.

"Treatment of Lymphogranuloma Venereum and Granuloma Inguinale with Antibiotics," Robert B. Greenblatt, University of Georgia Medical School, Augusta, Ga.

"An Antibiotic with Trypanocidal Properties," R. J. Schnitzer Chemotherapy Laboratory, Hoffman-La Roche, Nutley, N. J.

"Action of Antibiotics Against Intestinal Amoebae *in vitro*," William Balamuth, Northwestern University, Evanston, Ill.

"Antibiotics in the Treatment of Acute Amebic Dysentery," William W. Frye, School of Medicine, Louisiana State University, New Orleans, La.

"Treatment of Amebiasis with Terramycin and Other Antibiotics," Harry Most, New York University College of Medicine, Bellevue Medical Center, New York, N. Y.

Afternoon Session. Chairman, G. Robert Coatney, Laboratory of Tropical Diseases, National Microbiological Institute, Bethesda, Md.

"The Use of Fumagillin in Amebiasis," Hamilton H. Anderson, University of California Medical School, San Francisco, Calif.

"Treatment of Amebiasis with Aureomycin and Bacitracin," Howard B. Shookhoff and Max M. Sterman, Bureau of Laboratories, New York City Department of Health, New York, N. Y.

"Treatment of *Balantidium coli* Infections with Antibiotics," Martin D. Young, U. S. Public Health Service, Columbia, S. C.

"Use of Antibiotics in the Treatment of Helminthic

Infections," H. W. Brown, Columbia University School of Public Health, New York, N. Y.

"Antibiotics in Veterinary Tropical Diseases," C. D. W. Coles, Department of Veterinary Medicine, Department of Agriculture, Onderstepoort, South Africa.

"Treatment of Mycoses with Antibiotics" Frederick Reiss, New York University Post-Graduate Medical School, New York, N. Y.

"Treatment of Leprosy with Antibiotics," F. A. Johansen, and Paul T. Erikson, U. S. Public Health Service Hospital, Carville, La., and Public Health Service, Lexington, Ky.

Saturday, January 19

Morning Session. Chairman, Harold J. Magnuson, Venereal Disease Experimental Laboratory, University of North Carolina, Chapel Hill, N. C.

"The Use of Antibiotics in Spirochaetosis, Laboratory and General Considerations," Harold J. Magnuson, Venereal Disease Experimental Laboratory, University of North Carolina, Chapel Hill, N. C.

"Treatment of Bejel with Antibiotics," E. Herndon Hudson, Ohio University, Athens, Ohio.

"Treatment of Yaws with Antibiotics," C. R. Rein, New York, N. Y.

"Treatment of Pinta with Antibiotics," D. K, Kitchen, Bristol Laboratories, Incorporated, New York, N. Y.

"Treatment of Leptospirosis with Antibiotics," Parker R. Beamer, The Bowman Gray School of Medicine, Winston-Salem, N. C.

Afternoon Session. Chairman, Harold Brown, Columbia University School of Public Health, New York, N. Y.

"Treatment of Relapsing Fever with Antibiotics," V. T. Schuhardt University of Texas, Austin, Texas.

"Treatment of Bartonellosis with Antibiotics," V. T. DeVault, Medical Director, Foreign Service of the United States of America, Washington, D. C.

"Experimental Treatment of Plague in Animals with Antibiotics," K. F. Myer, The George Williams Hooper Foundation, University of California Medical Center, San Francisco, Calif.

"Antibiotics in the Treatment of Bubonic and Pneumonic Plague in Man," Joseph E. Smadel, Army Medical Service Graduate School, Washington, D. C.

"BIOLOGY OF THE TESTES"

JANUARY 25 AND 26, 1952

The Section of Biology held a Conference on "Biology of the Testes." Warren O. Nelson, State University of Iowa, College of Medicine, Iowa City, Iowa, *and* John MacLeod, Cornell University Medical School, New York, N. Y. were the Conference Chairmen in charge of the meeting.

The program consisted of the following papers:

Friday, January 25

Morning Session. "Spermatogenesis and Sperm Maturation." Chairman, John MacLeod, Cornell University Medical School, New York, N. Y.

"Definition of the Stages of the Cycle of the Seminiferous Epithelium of the Rat," Charles Leblond and Y. Clermont, McGill University, Montreal, Quebec, Canada.

"Kinetics of Spermatogenesis in Mammals," Edward C. Roosen-Runge, University of Louisville, School of Medicine, Louisville, Ky.

"Some Functions of the Caput Epididymis," Karl E. Mason, University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.

"Comparative Metabolic Behavior of Epididymal and Ejaculated Mammalian Spermatozoa," Henry A. Lardy, University of Wisconsin, Madison, Wis.

Afternoon Session. "Morphology and Cytochemistry. Chairman, William W. Scott, Johns Hopkins University, Baltimore, Maryland.

"Testicular Developmental Histology," Charles Charny, Philadelphia, Pa.

"Histology of the Testis at Puberty," Ronald Sniffen, Memorial Hospital, Worcester, Mass.

"Cytochemistry of the Testis," Margaret Long, College of Physicians and Surgeons, Columbia University, N. Y.

"Some Histochemical Observations of Human Testis," William Montagna, Brown University, Providence, R. I.

Saturday, January 26

Morning Session. "Hormonal Relations." Chairman, Robert Hotchkiss, New York University-Bellevue Medical Center, New York, N. Y.

"Indications for the Technique (Surgical) of Testicular Biopsy," Fred A. Simmons, Boston, Mass.

"Hormone Production by the Human Testis," William O. Maddock, Warren O. Nelson and Manuel Epstein, Wayne University, Department of Medicine, Detroit, Mich. and State University of Iowa, College of Medicine, Iowa City, Iowa.

"The Role of the Seminiferous Tubules in the Production of Hormones," E. Perry McCullagh, Cleveland, Ohio.

"Correlation Between Gonadotrophin Titers and Gonadotrophic Activity," Carl G. Heller, Warren O, Nelson, C. Alvin Paulsen and Glen E. Mortimore, University of Oregon Medical School, Portland, Ore. and State University of Iowa, College of Medicine, Iowa City, Iowa.

Afternoon Session. "Spermatogenesis and Effects of Steroids on the Testis." Chairman, Warren O. Nelson, State University of Iowa, College of Medicine, Iowa City, Iowa.

"Questions on the Cytodynamics of Spermatogenic Arrest of the Human Testis," Earl T. Engle, College of Physicians and Surgeons, Columbia University, New York, N. Y.

"The Kinetics of Spermatogenesis as Revealed by Changes in the Ejaculate," John MacLeod, Cornell University Medical School, New York, N. Y.

"The Effects of Testosterone Propionate Upon the Spermatogenic Function of the Human Testis," Norris Heckel, College of Medicine of the University of Chicago, Chicago, Ill.

"The Recovery of Spermatogenesis After Estrogen Therapy," Kenneth C. Lynch, Medical College of the State of South Carolina, Charleston, S. C.

The Section of Biology provides conferences for active workers in the special fields of Biology.

Attendance is limited to those invited to participate in these conferences and to interested Members of the Academy.

NEW MEMBERS

A. Elected January 24, 1952

CORPORATION MEMBERSHIP

The Ciba Pharmaceutical Products Inc., Summit, New Jersey.

LIFE MEMBERSHIP

Ott, Emil, D.SC., Chemistry. Director of Research, Hercules Powder Company, Wilmington, Del.

SUSTAINING MEMBERSHIP

Allen, Peter, B.A., Microbiology. Grad. Student, Columbia Univ., New York, N. Y.

Murphree, Eger V., B.S. Petroleum. President, Standard Oil Development Co., New York, N. Y.

Walden, Richard Henry, M.D., Plastic & Reconstructive Surgery. Attending Plastic Surgeon, Nassau Hosp., West Hempstead, L. I., N. Y.

ACTIVE MEMBERSHIP

Ago, Damaceno J., M.D., Medicine & General Surgery. Director & Chief Surgeon, Naga City Hospital, Philippines.

Anderson, Kenneth E., PH.D., Microbiology. Chairman, Dept. of Biology, St. Bonaventure University. St. Bonaventure, N. Y.

Aronson, Shepard G., M.D., Internal Medicine. Clinical Instructor, N. Y. U. Bellevue Medical Center, New York, N. Y.

Baker, Carl G., M.D., Biochemistry. Senior Assisting Surgeon, U. S. Pub. Health Service, Bethesda, Md.

Baker, Walter Wolf, M.S., Pharmacology. Res. Admin. Assist. in Pharmacology, Wyeth Inst., Philadelphia, Pa.

Barondess, Jeremiah A., M.D., Internal Medicine. Assistant Surgeon, U. S. Public Health Service, Children's Hosp., Philadelphia, Pa.

Beaty, Mary Bak, Drugs, Cosmetics, Food. Acting Director, Scientific Res., J. Walter Thompson. New York, N. Y.

Behrman, Howard, M.D., Dermatology. Chief of Clinics, Mt. Sinai Hosp., New York, N. Y.

Belloff, George, D.V.M., Pharmacology. Veterinarian, East Orange, N. J.

Bellows, Marjorie T., M.S., Biostatistics. Statistician, American Heart Assoc., New York, N. Y.

Blanchet, Louis John, M.S., Biochemistry. Grad. Student, Chicago, Ill.

Blank, Harvey, M.D., Medicine. Assoc. Med. Director, E. R. Squibb & Sons, New York, N. Y.

Boccabella, Anthony V., B.S., Biology. Res. Assist., Brooklyn, N. Y.

Boniece, William S., PH., Virology, Bacteriology. Research, Biol. Res. Div., The Lilly Res. Labs., Indianapolis, Ind.

Bonventre, Martin Victor, M.D., Internal Medicine. Assistant in Med., St. Catherine Hospital, Brooklyn, N. Y.

Boss, W. R., Biology. Professor of Zoology, Dept. of Zoology, Syracuse Univ., Syracuse, N. Y.

Brand, Henry, M.D., Ophthalmology. Res. Assoc. N. Y. Eye & Ear Infirmary, New York, N. Y.

Brandt, Milton W., B.S., Biology. Bacteriologist, Dept. of Health, Spokane, Wash.

Breger, Irving A., PH.D., Geochemistry. Res. Assoc. in Geology, Mass. Inst. of Technology, Cambridge, Mass.

Brooks, Lewis, M.D., Pathology. Resident, Mt. Sinai Hosp., New York, N. Y.

Brown, Raymond A., PH.D., Physical Biochemistry. Research Chemist, Lederle Labs., Pearl River, N. Y.

Burke, Ruth Cutter, PH.D., Medical Mycology. Res. Assoc., Harvard Med. School, Boston, Mass.

Burns, Benedict D., M.R.C.S., Properties of Synapses. Assoc. Prof. Physiology, McGill Univ., Montreal, Canada.

Calhoon, Thomas B., B.A., Physiology. Grad. Student, Ohio State Univ., Columbus, Ohio.

Cameron, Mary Helen, M.D., Medicine. Instructor in radiology. Woman's Med. Coll. of Pennsylvania, Philadelphia, Pa.

Chassin, Jameson L., M.D., Surgery. Instructor in Surgery, N. Y., Univ., Bellevue Med. Center, New York, N. Y.

Ciner, Leonard F., M.D., Medicine. Assoc. Gynecologist, Lenox Hill Hosp., New York, N. Y.

Coe, Jr., Fred A., B.S., Medicine. Distribution Manager, Burroughs Wellcome & Co., Tuckahoe, N. Y.

Cosgrove, John F., B.S., Bacteriology. Head, Dept. of Bacteriology, Hoffman La Roche Inc., Nutley, N. J.

Crotty, Joseph George, M.D., Obstetrics & Gynecology. Private Practice, Cincinnati, Ohio.

Danza, Anthony L., M.D., Chemotherapy of Cancer. Res. Fellow in Cancer, Maimonides Hosp., New York, N. Y.

Deane, Mary Sheila, B.A., M.A., Geology. Res. Assistant, Columbia Univ., New York, N. Y.

De Leeuw, Nannie K. M., M.D., Hematology. Res. Fellow in Hematology, Ohio State Univ., Columbus, Ohio.

Deverill, Merwyn W., B.A., Bacteriology. Grad. Student, Univ. of Delaware, Newark, Del.

Diamond, Henry David, M.D., Cancer. Assistant Attending Physician, The Memorial Centre for Cancer, New York, N. Y.

Dorsey, Jr., Robert L., Ph.D., Endocrinology, Cancer Res. Public Health Fellow, Rutgers Univ., New Brunswick, N. J.

Dutcher, Ray M., B.S., Microbiology. Res. Biologist, Lederle Labs., Pearl River, N. Y.

Elam, James O., M.D., Physiology. Assistant Professor, Div. of Anesthesiology, Dept. of Surgery, Washington Univ., School of Med., St. Louis, Mo.

Emery, Gertrude C., M.S., Biology. Res. Assoc., New York, N. Y.

Engel, Milton, Anatomy. In residence. Montefiore Hosp., Pittsburgh, Pa.

Field, John Byron, M.D., Blood Coagulation. Assist. Clin. Prof. of Medicine, Univ. of Southern Calif., Los Angeles, Calif.

Finlay, Alexander, M.S., Biology. Assist. Director, Biochem. Research, Chas. Pfizer & Co., Brooklyn, N. Y.

Fogg, Roland Arthur, M.A., Psychology. Junior Res. Assist., Dunlap & Assoc. Inc., Stamford, Conn.

Friedgood, Charles E., M.D., Surgical Res., Clinical Associate, State Univ., of N. Y., Brooklyn, N. Y.

Gabaldon, Arnoldo, D.Sc., Malariology. Adviser, Div. of Malariologia, Maracay, Venezuela.

Gabrieli, Elemer Rudolph, M.D., Radiobiology. Instructor, Section of Med. Physics, Yale Univ., New Haven, Conn.

Gamble, Clarence J., M.D., Res. in Contraceptive Fields. Cincinnati, Ohio.

Gardocki, Joseph F., Ph.D., Pharmacology. Senior Pharmacologist, Chas. Pfizer & Co., Brooklyn, N. Y.

Garrett, Thomas A., M.D., Virus Diseases. Med. Service Dept., Chas. Pfizer & Co., Brooklyn, N. Y.

Ginger, Leonard G., Ph.D., Bacterial Chemistry. Assist. Scientific Director, Baxter Labs., Inc., Morton Grove, Ill.

Glickman, Charles S., B.S., Wax & Colloid Res. Chief Chemist, Old Town Corp., Brooklyn, N. Y.

Glicksman, Arvin S., M.D., Clinical Investigation, Biochemistry. Brookhaven Ntl. Lab., Upton, L. I., N. Y.

Gray, Irving, Ph.D., Biochemistry. Chief, Lab. Division, Brooke Army Hospital, Fort Sam Houston, Texas.

Halligan, Earl J., M.D., Surgery. Director of Surgery, Jersey City Med. Center, Jersey City, N. J.

Harris, Elliott S., M.S., Biochemistry. Instructor of Biochemistry, University of Southern California, Los Angeles, Cal.

Harvey, Max J., D.V.M., Veterinary Medicine. Clinical Research, Lederle Labs., Pearl River, N. Y.

Henderson, Francis G., M.D., Pharmacology. Pharmacologist, Eli Lilly & Co., Indianapolis, Indiana.

Herbst, William, B.S., Chemistry, Biochemistry. Chief Production Chemist, Holland-Rantos Inc., Trenton, N. J.

Hewes, Walter E., Jr., M.S., Bacteriology. Bacteriologist, E. I. du Pont de Nemours & Co., New Castle, Delaware.

Hirsch, Dorothy T., B.A., Bacteriology. Bacteriologist, St. Vincent's Hospital, New York, N. Y.

Hodas, Joseph Henry, M.D., Medicine. Attending Physician, City Hospital, New York, N. Y.

Homer, George M., M.S., Biochemistry. Research Assistant, Pharmacology Dept., Wyeth Inst., Philadelphia, Pa.

Horowitz, Franklin, B.A., Phagocytic Activity. Med. Student, Brooklyn, N. Y.

Horwitz, Norman, M.D., Anesthesiology. Adjunct Anesthesiologist, Beth Israel Hospital, New York, N. Y.

Howe, Calderon, M.D., Immunology. Fellow of Ntl. Foundation for Infantile Paralysis, Dept. of Bacteriology, Coll. of Physicians & Surgeons, Columbia Univ., New York, N. Y.

Hudyma, George M., B.S., Physiology. Assist. Res., Physiology., Philadelphia, Pa.

Hughes, Mary F., M.A., Carbohydrate Chemistry. Director of Research, Refined Syrups & Sugars Inc., Yonkers, N. Y.

Hynard, Edward Ormond, M.A., Mathematics. Instructor in Mathematics, Manhattan Coll.

Ilavsky, Jan, M.D., Biology. Head of Dept. of Bacteriology, Schering Corp., Bloomfield, N. J.

Innerfield, Irving, M.D., Liver, Pancreas. Lecturer in Physiology, Dept. of Physiology, N. Y., Medical Coll., New York, N. Y.

Jacox, Ralph F., M.D., Internal Medicine. Asst. Prof. of Medicine, Univ. of Rochester, Rochester, N. Y.

Johnson, Kenneth Gerald, M.D., Hypertension. Clinical Fellow, Yale Univ., New Haven, Conn.

Kao, Frederick F. T., Ph.D., Physiology. Instructor, Section of Med. Physics, Yale Univ., New Haven, Conn.

Keasling, Hugh H., Ph.D., Pharmacology. Assoc. Dept. of Pharmacology, Coll. of Medicine, State Univ., of Iowa, Iowa City, Iowa.

Knight, Vernon, M.D., Medicine. Inst. Med., Cornell Univ., New York, N. Y.

Koree, Jean U., Geology, Mineralogy. President, Jacques Loewe Research Foundation, New York, N. Y.

Korkosz, August B., M.D., General Surgery. Attending in Surgery, Ellis Hospital, Schenectady, N. Y.

Kostelak, Edward, B.S., Microbiology. Microbiologist, Hoffman La Roche, Nutley, N. J.

Koten, I. A., Ph.D., Chemistry. Prof. of Chemistry, North Central Coll., Naperville, Ill.

Lane, Dorothy, M.S., Microbial Genetics & Biochemistry. Research Worker, Urology Labs., Delafield Hosp., New York, N. Y.

Larson, Kermit H., M.S., Soil Chemistry. Chief, Alamogordo Section, Univ., of Cal., Atomic Energy Project, Los Angeles, Cal.

Leo, Amandus, Engineering. Dean of the School of Engineering, Manhattan Coll., New York, N. Y.

Levine, Arthur H., M.D., Surgical Physiology. Fellow in Surgical Research, Bayside, L. I., N. Y.

Little, David M., Jr., Biology. Assistant Clinical Prof. of Anesthesiology, Yale Univ., Stamford, Conn.

Localio, S. Arthur, M.D., Wound Healing. Assoc. Prof. of Clinical Surgery, Med. School, N. Y. University, New York, N. Y.

London, Morris, Ph.D., Biochemistry. Research Chemist, Coll. of Physicians & Surgeons, Columbia Univ., New York, N. Y.

Macchi, Italo Alden, M.A., Adrenal Biochemistry. Grad. Student, Boston University. In residence Worcester Foundation Exp. Biology, Shrewsbury, Mass.

Maren, Thomas H., M.D., Chemotherapy, Endocrinology. Pharmacologist, Stamford, Conn.

Masley, Peter M., M.S., Medicine, Biochemistry. Student, N. Y. Medical College, New York, N. Y.

McEntee, Kenneth, D.V.M., Pathology of Reproductive Disorders of Cattle. Associate Prof. of Veterinary Pathology, N. Y. State Veterinary Coll., Ithaca, N. Y.

Meigher, Stephen C., M.D., Surgery. Attending Surgeon, Ellis Hospital, Schenectady, N. Y.

Melville, Kenneth Ivan, M.D., Cardiovascular Pharmacology. Assoc. Prof. of Pharmacology, McGill Univ., Montreal, Canada.

Metzger, Joseph F., M.D., Tissue Culture. Resident in Pathology, Walter Reed Army Hosp., Washington, D. C.

Miller, Herbert L., M.D., Medicine & Biology. Physician, Fairview State Hospital, Penn.

Miranda, Jose Lisboa, M.D., Mycology. Staff, Instituto Oswald. Cruz, Rio de Janeiro Brazil.

Moses, William, Ph.D., Metabolism & Enzyme Chemistry. Chemist, Wallerstein Labs., New York, N. Y.

Moulder, James W., Ph.D., Biochemistry. Assist. Prof. of Biochemistry, Dept. of Bacteriology, Chicago, Ill.

Mozingo, Hugh Nelson, Ph.D., Morphology. Assoc. Prof. of Biology, Florida Southern Coll., Lakeland, Fla.

Mulford, Edwin H., M.D., Neurosurgery. Norwalk General Hospital, Norwalk, Conn.

Munan, Louis P., M.S., Endocrinology, Nutrition, Burns. Associate in Physiology, George Washington Univ., Med. School, Washington, D. C.

Mikitin, A. A., Ph.D., Chemistry. Director, Agricultural Research, Tennessee Corp., College Park, Ga.

Orentreich, Norman, M.D., Dermatology. Fellow Skin & Cancer Unit, New York, N. Y.

Orth, O. S., M.D., Pharmacology. Prof. of Pharmacology & Surgery, University of Wisconsin, Madison, Wis.

Packman, Elias W., B.Sc., Pharmacology. Grad. Student, Philadelphia Coll., of Pharm., & Science, Philadelphia, Pa.

Pallin, Irving M., M.D., Anesthesiology. Attending Anesthesiologist, Jewish Hosp., Brooklyn, N. Y.

Pan, S. C., Ph.D., Fermentation Biochemistry. Research Assoc., Research & Develop. Labs., E. R. Squibb & Sons, New Brunswick, N. J.

Pappas, Alexis C., Radiochemistry. Assistant Prof., Dept. of Chemistry, Univ. of Oslo, Oslo, Norway.

Papper, Emanuel M., M.D., Anesthesiology. Prof. of Anesthesiology, Columbia Univ., New York, N. Y.

Pelikan, Edward W., M.D., General Pharmacology. Instructor, Dept. of Pharmacology Univ. of Illinois, Chicago, Ill.

Pfaltz, Mimosa, Ph.D., Organic & Biological Chemistry. Research Chemist, Physiological Chemical Co., New Rochelle, N. Y.

Phillips, Lida, B.A., Hematology. Res. Technician in Nutrition Dept., Merck Inst., Rahway, N. J.

Pugh, Leonora H., M.S., Virology. Research Assoc., Rutgers Univ., New Brunswick, N. J.

Quaranta, John V., M.A., Psychology. Instructor in Psychology, Manhattan Coll., New York, N. Y.

Quastel, J. H., Ph.D., Biochemistry. Prof. of Biochemistry, McGill Univ., Montreal, Canada.

Ravett, Annette, B.S., Physiology. Res. Assistant in Surgical Laboratory, Brooklyn, N. Y.

Reames, Harold R., M.D., Infectious Diseases. Staff Physician, Upjohn Co., Kalamazoo, Mich.

Reichenthal, Jules, B.A., Biochemistry. Chemist, Ntl. Insts. of Health, Bethesda, Md.

Rennick, Barbara Ruth, M.D., Renal Physiology. Instructor, State Univ., of N. Y. Med. Center. Syracuse, N. Y.

Reissner, Albert, M.D., Zoology, Psychology. Consulting Psychologist, Brooklyn, N. Y.

Rich, Barnett, Ph.D., Maths. Education. Chairman of Maths. in High School, New York, N. Y.

Rich, Saul, Ph.D., Biology. Assoc. Pathologist, Conn. Agric. Exp. Station, New Haven, Conn.

Robertazzi, Raphael W., M.D., Anesthesiology. Prof. Clin. Anesthesiology, N. Y. Post Grad., Med. School, New York, N. Y.

Robertson, James Sydner, Ph.D., Biophysics. Head, Div. of Biophysics, Med. Div. Brookhaven Ntl. Lab., Upton, L. I., N. Y.

Rockwell, Harriet B., Ph.D., Cardiovascular Pharmacology, Biochemistry. Lit. Scientist, Smith, Kline & French Labs., Philadelphia, Pa.

Roodenburg, Andries I., M.D., Medicine. Private Practice, Rochester, N. Y.

Rothlauf, Mary U., B.A., Medical Microbiology. Chief Technician, Microbiology, Nepera Chemical Co., Yonkers, N. Y.

Scanlan, John S., M.D., Clinical Research. Assist. Med. Director, Ayerst McKenon & Harrison, New York, N. Y.

Sanders, Irwin T., Sociology. Director, Bureau of Community Service, Univ. of Kentucky, Lexington, Kentucky.

Sartorius, Otto W., M.D., Renal Physiology. Assistant Prof. of Physiology & Medicine, State Univ. of N. Y. Med. Center, Syracuse, N. Y.

Seaman, John H., B.A., Psychobiology. Med. Student, Albany Med. Coll., Albany, N. Y.

Shafer, Henry Burnell, Ph.D., Chairman, Dept. of Social Studies, Walton H. S., New York, N. Y.

Shakespeare, Nancy E., M.S., Organic Chemistry. Res. Chemist, Amrican Cyanamid Co., Stamford, Conn.

Shepard, Paul, J.S.D., Lawyer. International Law & Anthropology. New York, N. Y.

Sherman, Irving Richard, Ph.D., Biochemistry. Res. Assistant, Section of Med. Physics, Yale Univ., New Haven, Conn.

Shnayerson, Ned, M.D., Vascular Disease. Clin. Prof. Surgery, N. Y. Polyclinic Hosp., New York, N. Y.

Simmons, Ingalls, H., M.D., Public Health. Chief of Preventive Medicine, Fort Dix, N. J.

Simuangco, S. A., M.D., Dermatology. Assistant Prof., St. Tomas Univ., Manila, Philippines.

Sookman, George, B.S., Polymer Chem. Chemist, New York, N. Y.

Steckler, Robert, Ph.D., Chemistry. Industrial Consultant, R. Steckler Labs., Steckler Labs., South Euclid, Ohio.

Stein, Edna, B.A., Bacteriology. Assist. Bacteriologist, Bellevue Hosp., New York, N. Y.

Steinfeld, Jesse Leonard, M.D., Medicine, Biochemistry. Atomic Energy Commission, Post Doctoral Res. Fellowship in Med. Sciences, Reed Coll., Portland, Oregon.

Steinman, David, B.S., Medicine. Medical Student, New York, N. Y.

Steinman, Max, M.D., Internal Medicine. Chief Resident, Goldwater Memorial Hosp., New York, N. Y.

Streitfeld, Franklin H., M.D., Medicine. Res. Physician, Mt. Sinai Hospital, New York, N. Y.

Sutherland, George Leslie, Ph.D., Organic Chemistry. Res. Chemist, Chemotherapy Div., American Cyanamid Co., Stamford, Conn.

Swift, Marjorie E., M.A., Mycology. Mycologist, Heyden Chem. Corp., Princeton, N. J.

Syverton, Jerome T., M.D., Viruses & Infectious Diseases. Head of Dept. of Bacteriology, University of Minnesota, Minneapolis, Minn.

Taves, Ernest H., M.D., Psychiatry, Psychology. Private Practice of Psychiatry, New York, N. Y.

Thoma, Richard W., Ph.D., Biochemistry, Microbiology. Biochemist, Div. of Microbiology, E. R. Squibb & Sons, New Brunswick, N. J.

Thomas, Leon L., Ph.D., Psychology. Sr. Research Associate, Dunlap & Associates, Stamford, Conn.

Tice, L. F., B.Sc., Pharmacy. Assist. Dean, Phila. Coll. of Pharmacy & Science, Philadelphia, Pa.

Tirunarayanan, M. O., Biochemistry. Biochem. Lab. Univ. of Madras, Madras, India.

Traficante, Anthony J., B.A., Bacteriology. Jr. Bacteriologist, Bureau of Labs., N. Y. Health Dept., New York, N. Y.

Tusubi, Kenneth, Urology. City of N. Y. Dept. of Hospitals, Francis Delafield Hosp., New York, N. Y.

Vanamee, Parker, M.D., Medicine, Biology. Assistant Res. Medicine, Memorial Center, New York, N. Y.

Vinograd, Jerome R., Ph.D., Physical Chemistry. Senior Research Fellow in Chemistry, Cal. Inst. of Technology, San Marino, Calif.

Volkmann, Ernest W., Ph.D., Coal Carbonization & Coal-tar Technology. Assoc. Manager, Res. Dept., Koppers Co., Inc., Pittsburgh, Pa.

Vroman, Leo, M.S., Medical Physics. Hematology. Res. Assoc. St. Peter's General Hosp., New Brunswick, N. J.

Wagner, Robert R., M.D., Medicine & Biology. Instructor in Medicine, Yale Univ., New Haven, Conn.

Waller, Ernest F., D.V.M., Infectious Poultry Diseases. Professor & Head of Dept. of Animal & Poultry Industry, Univ. of Delaware, Newark, Del.

Walton, William W., Ph.D., Surface Chemistry. Assist. Chief Surface Chemistry, Ntl. Bureau of Standards, Washington, D. C.

Webb, Joseph P., B.A., Clinical Pharmacology. Staff Physican, Med. Div., The Upjohn Co., Kalamazoo, Mich.

Weinstein, Jules H., D.D.S., Hypnosis. Private Practice, Dentist, New York, N. Y.

Weisselberg, Arnold, Heat Transfer. Consulting Engineer, Long Island City, N. Y.

Wershaw, Irving, B.S., Pharmacology. Vice President, Dome Chemicals Inc., New York, N. Y.

Woods, Jr., Clifton J., M.S., Bacteriology. Bacteriologist, Antibiotic Control Lab., Vet. Admin. Hosp., Hines, Ill.

Yudell, Jack, B.S., Bacteriology. Student, Univ. of Oklahoma, Norman Okla.

Zacks, Sumner, B.A., Histochemistry. Med. Student, Harvard Med. School, Boston, Mass.

Zakin, David, M.D., Obstetrics & Gynecology. Assoc. in Obstetrics, Lincoln Hosp., New York, N. Y.

Zarafonatis, Chris J. D., M.D., Internal Medicine. Assoc. Prof., in Knternal Med., Temple Univ., Hosp., Philadelphia, Pa.

Zelitch, Israel, Ph.D., Biochemistry. Ntl. Res. Council Postdoctoral Fellow, Dept. of Pharmacology, N. Y. U., Coll. of Medicine, New York, N. Y.

Zimmerman, Carle C., Anthropology. Sociologist, Harvard Univ., Cambridge, Mass.

STUDENT MEMBERSHIP

Alpern, Joshua Jehuda, B.S., Grad. Student, New York. N. Y.

Berdick, Murray, M.S., High Polymer Chemistry. Student, Polytechnic Inst. of Brooklyn, Brooklyn, N. Y.

Burns, Padraic, B.A., Medicine, Med. Student, New York, N. Y.

Crowder, John Nathaniel, B.S., Medicine. Student, Haddonfield, N. J.

Dornfest, Albert, B.S., Physiology, Biochemistry. Student, Columbia Univ., New York, N. Y.

Farb, Harry, Psychiatry. Student, Psychiatry, Bellevue Hosp., N. Y. U., New York, N. Y.

Kratchman, Jack, B.S., Geology. Student, New York Univ., New York, N. Y.

Ljostad, Bessie, B.A., Geology. Lab. Assistant, Dept. of Geology, Hunter Coll., New York, N. Y.

Moreno, Antoinette, Bio-metrics. Student, New York, N. Y.

Ottolenghi, Abramo, B.S., Biochemistry. Student, Rutgers Univ., New Brunswick, N. J.

Shaine, David, B.A., Biology. Student, New York Univ., New York, N. Y.

Tolor, Alexander, M.A., Clinical Psychology. Graduate, Psychology, New York Univ., New York, N. Y.